Evaluation of Land Use Impacts on Environmental Quality in Urban and Semi-rural Streams Tributary to Great South Bay Long Island, New York

EVALUATION OF LAND USE IMPACTS ON ENVIRONMENTAL QUALITY IN URBAN AND SEMI-RURAL STREAMS TRIBUTARY TO GREAT SOUTH BAY, LONG ISLAND, NEW YORK

Dr. Lee E. Koppelman
Project Director

DeWitt S. Davies
Project Coordinator

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Long Island Regional Planning Board
H. Lee Dennison Office Building
Veterans Memorial Highway
Hauppauge, New York 11788-5401

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STUDY PARTICIPANTS

Project Director
Dr. Lee E. Koppelman

Report Preparation
DeWitt S. Davies
Lauretta R. Fischer
Christine Viladesau

Technical Advisors
Living Marine Resources Institute
Marine Sciences Research Center
SUNY @ Stony Brook
W.M. Wise
B. Li
S. Jonasdottir
W-S. Kim

Consulting Engineer
Eugene D. Driscoll

Support Staff
Sandy Martin
Jeanne Widmayer

Cartographic and Publication
Anthony Tucci
Carl Lind
Thomas Frisenda

Accounting
Lucille Gardella

Preface

Regional investigations have documented that pollutants from nonpoint sources constitute a large proportion of the contaminants entering Long Island's ground water and aquatic and marine surface waters. Nonpoint source pollution emanates from many small sources spread diffusely over an area, which in the aggregate cause water quality degradation. Stormwater runoff from impervious surfaces, overland flow, domestic on-site wastewater disposal systems, agricultural chemical use, removal of riparian vegetation, streambank disturbance, landfill leachate, boat pollution and spills, accidents and leaks of hazardous materials associated with poor housekeeping at industrial and commercial facilities are typical sources and activities that contribute to the nonpoint source problem on Long Island. In addition, acid rain is an area-wide nonpoint source. Point sources of pollution result from a discharge at a specific single location (e.g., a sewage treatment plant outfall pipe) and are regulated by a clearly identifiable agency. In contrast, the prevention/reduction of nonpoint source contaminant loadings can only be achieved by actions taken by many agencies at all levels of government that modify land and water uses and practices, and by knowledgeable citizens in the conduct of their daily activities.

On a bay-wide basis, pollutant loadings to Great South Bay and its tributary streams are predominantly from nonpoint sources. In this report, the relationship between land uses and water/environmental quality in stream corridor environments tributary to the bay is investigated. A case study approach was utilized wherein two stream watersheds were investigated in detail — one indicative of urban conditions, and the other typifying the semi-rural pattern of development along the south shore of Long Island. Hence, the scope of this study is local in nature, but the approach used to identify problems and opportunities can be applied to other areas experiencing similar surface water problems due to nonpoint source pollution. Recommendations are made for each of the watersheds for the control and/or mitigation of nonpoint pollution to the stream environments, and ultimately to Great South Bay. Particular attention has been given to the control of stormwater runoff and overland flow. The recommendations reflect the different density of development found within the two areas; they are also designed to achieve other natural resource and open space objectives, particularly in the semi-rural watershed where prevention is the philosophy employed. This is reflected in the reliance on land use alternatives to mitigate nonpoint sources and to preserve the stream corridor. For the urban stream watershed, fewer options are available from both the structural and non-structural points of view. Here, source control options and stream maintenance have been emphasized.

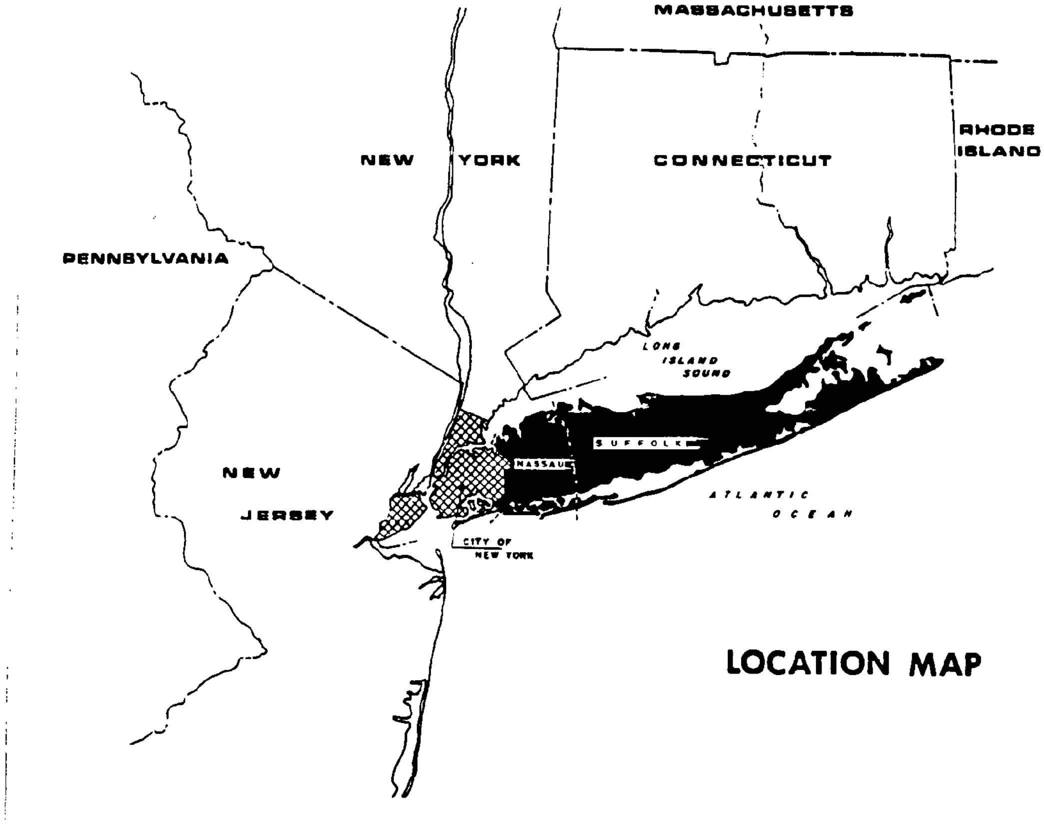
The principal recommendation in the report is the need to establish stream corridor protection programs at the town level having public education, litter reduction, stream corridor improvement and surveillance components. The programs would provide a means for coordinating New York State, Suffolk County, town and village activities targeted to the development and implementation of protection plans on a priority basis for all of the streams tributary to Great South Bay.

Table of Contents

List of Figures

List of Tables

List of Maps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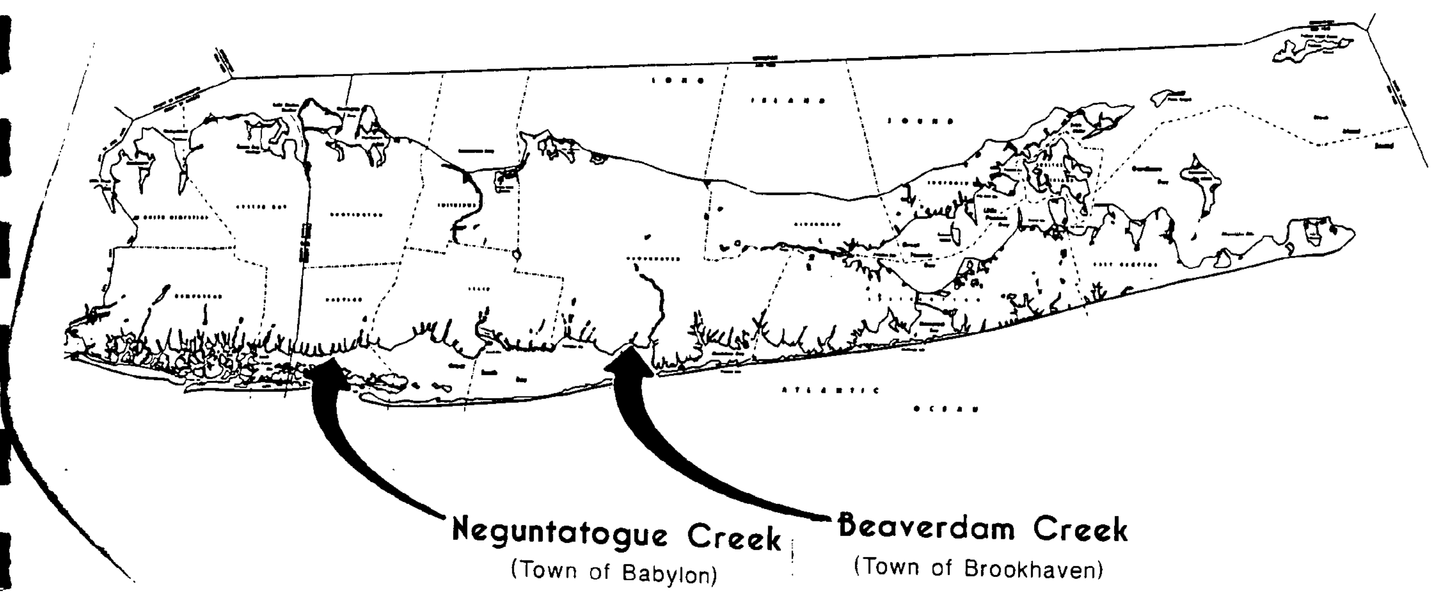
ATLANTIC OCEAN
CITY OF NEW YORK
LOCATION MAP


Neguntatogue Creek
(Town of Babylon)
Beaverdam Creek
(Town of Brookhaven)

Chapter One

Introduction

Great South Bay is a large shallow estuary about 25 miles long, between 1 and 6 miles wide, and averaging 4 feet in depth. The bay is on the south shore of Long Island stretching from near the Nassau County line to the narrow straight between Bellport Bay and Moriches Bay. The bay is protected from the Atlantic Ocean by barrier islands. (See Figure 1-1.) Fire Island Inlet allows direct exchange with the ocean with indirect exchange coming from Jones Inlet through South Oyster Bay to the west, and from Moriches Inlet through Moriches and Narrows Bays, to the east.

Thirty-eight streams discharge into Great South Bay. While few of these streams have been extensively studied throughout their fresh-water and marine reaches, available evidence suggests that, in their natural state, they were probably quite similar. The surficial sediment along most of the southern portion of Long Island is composed of glacial outwash sands, deposited by streams during the most recent glacial retreat. The original northern shoreline of Great South Bay was composed of sandy beaches punctuated by these numerous small streams, which were originally fed by glacial meltwaters, but were partially drowned by the advancing sea and are now fed almost exclusively by ground water from Long Island's aquifers (Suffolk County Executive Office: Special Projects 1980). Lining the marine portions of these streams were fringing salt marshes.

The mainland shoreline surrounding the western portion of Great South Bay has been greatly modified due to residential and commercial development; this area, which includes the shoreline within the Town of Babylon and the western half of the Town of Islip, is within the boundaries of Suffolk County Southwest Sewer District No. 3 (SWSD #3). The mainland shoreline bordering the eastern portion of Great South Bay, including the eastern portion of the Town of Islip and the Town of Brookhaven, has not been subjected to the same intensity of development as experienced in the western portion. Shoreline development along the eastern portion of Great South Bay is primarily serviced by on-site septic systems and cesspools; two small sewage treatment plants (STPs) with marine outfalls flow into Patchogue River.

The majority of the barrier beach shoreline bordering Great South Bay is publicly owned and used for recreational/open space purposes. The western end of Fire Island, east of Robert Moses State Park, contains 20 private residential summer communities. Only one of the communities, the Village of Ocean Beach, is serviced by a small STP which discharges into the Great South Bay.

Development of the Great South Bay watershed has resulted in impacts on the natural resources and environmental quality of the streams tributary to the bay and on the bay itself. The 38 streams that flow into Great South Bay are conduits by which pollutant loadings reach open bay waters. Indeed, the quality of bay waters is determined by the cumulative impacts of these stream loadings, ground-water underflow and ocean boundary conditions.

Great South Bay supports one of the nation's most productive hard clam fisheries. During the 21-year period from 1966-1986, an average of about 436,000 bushels of hard clams per year were landed in the Great South Bay fishery (Suffolk County Planning Dept. 1987). However, hard clam landings have plummeted since peak production occurred in 1976. Deterioration of water quality and increased closure of harvest grounds have been cited as potential factors contributing to the decline of the fishery. As of January 1990, 9,991 acres of the bay were closed to shellfishing (Charles deQuillfeldt pers. comm.); this amounted to 17.2% of total bay area (58,000 acres).

1.0 Purpose of this Study

There has been much experience associated with the preparation of comprehensive land use plans that focus on the aesthetic, efficient, and compatible distribution of land uses that address the needs of a population. These plans typically consider environmental resources as constraints on the development process. There is relatively little experience associated with planning for water use from the point of view of specifying the mix of land uses and activities that will not exceed the carrying capacity of marine systems, i.e., *...the ability of a natural or man-made system to absorb population growth or physical development without significant degradation or breakdown* (Schneider, Godschalk and Axler 1978). This is the crux of the problem in that there must be a determination of what the limitations of the marine environment are, albeit even in a gross sense, in terms of water and sediment quality, fish and wildlife populations, etc. The planner must then assess the extent that mixes of land and water use, i.e., alternative plans, are compatible with the limitations. The limitations must be described by the scientific community in the form of criteria that can be used to determine the controls that must be placed on land and water use and associated activities so as to achieve the desired ends.

Even the most cursory examination reveals the general gradation in marine water quality in New York from the highly stressed and degraded conditions in New York Harbor, the inner New York Bight, and extreme western Long Island Sound to the relatively undisturbed and unpolluted environment of eastern Long Island Sound, the Peconic-Gardiners Bay System, and coastal ocean waters off eastern Long Island. While the correlation between the density and extent of human development of coastal areas and the degree of degradation of adjacent coastal environments is clear, most coastal fringes on Long Island feature a wide array of development activity and land uses. In such situations, the identification of those land use(s), activities, etc. that are responsible for specific coastal water quality impacts becomes problematic. This study attempts to determine these links. Identifying in practical, useful terms how land use affects coastal marine water quality is a prerequisite to the formulation of new or revised land use regulations, engineering-based mitigation or remedial measures, and other actions that will better accommodate the pressure to develop/re-develop coastal areas and the need to preserve their ecological integrity and, thus, their economic and social importance to society.

The New York State Department of State (NYSDOS) identified the need to assess the adequacy of existing development standards and regulations in protecting water quality and ecosystems in the Great South Bay with the intent to aid local governments in preparing their Local Waterfront Revitalization Programs. The extent to which the

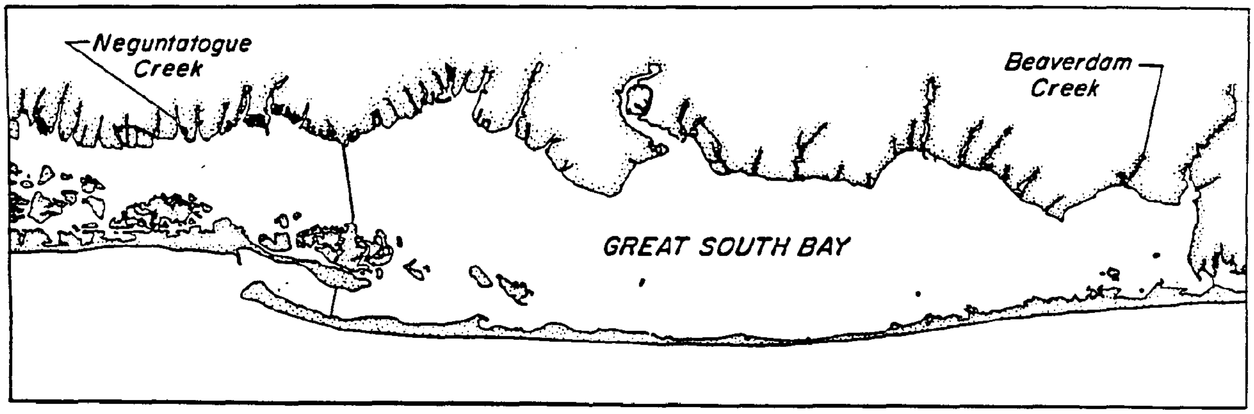


Figure 1-1 *Map of Great South Bay showing the locations of Neguntatogue and Beaverdam Creeks.*

regulatory approach can be used to maintain Great South Bay water quality and protect ecosystem function, in the face of development of vacant land and the redevelopment of shoreline areas, must be evaluated in light of the magnitude of current problems and conditions that represent the integrated impacts of historic land use and regulatory practice. While regional evaluations of land use and surface water quality relationships have been conducted for the Long Island area, the opportunity to determine the extent to which regulatory changes, land use policy and structural measures can be employed at the local level to maintain or improve surface water quality remained to be addressed.

With funding from the NYSDOS, the *Long Island Regional Planning Board* (LIRPB) has conducted this study on the extent to which land use patterns and activities have impacted the environmental quality of stream corridors along the northern margin of Great South Bay. The purpose of this study is to identify ways in which redevelopment of urbanized watersheds and development of semi-rural watersheds of Great South Bay can be planned and regulated to minimize impacts on the quality of adjacent freshwater and marine environments in the tributary streams.

1.1 Study Approach

Given the limitations on available resources to conduct this study, the LIRPB elected to utilize the prototype approach, whereby a comparative assessment of two stream corridors would be conducted — one representative of the development scenario and aquatic habitat found in urbanized portions of the Great South Bay watershed; and the other more typical of semi-rural conditions to the east.

Chapter 2 in this report describes the process used by the LIRPB to review the land use, environmental resources and water quality conditions within the 38 stream/river watersheds tributary to the bay in the Towns of Babylon, Islip and Brookhaven, and the rationale for the selection of the two case study watersheds. The Neguntatogue Creek watershed within the Town of Babylon was identified as the study area typifying urban conditions; the conditions in the Beaverdam Creek watershed within the Town of Brookhaven led to its selection as the semi-rural case study area.

Land use, environmental resources and other factors are inventoried and discussed for the two study watersheds in Chapter 3. The maps and text facilitate the comparison of conditions in the urban and semi-rural case study watersheds, and also provide the means whereby similar conditions/situations can be found when dealing with the watersheds of the remaining 36 streams tributary to Great South Bay.

Stream environmental quality is the subject of Chapter 4. The results of a field-based, water and environmental quality monitoring program conducted on the two streams are presented. Significant differences in environmental quality between the two streams and pollutant sources are identified and discussed.

Chapter 5 contains a review of the *Best Management Practices* (BMPs) that have potential for addressing nonpoint source (NPS) pollution problems in the Great South Bay watershed. General design criteria and advantages/disadvantages of the various options are discussed.

Potential courses of action for mitigating nonpoint sources of pollution to both creeks, and ultimately to Great South Bay, are the subject of Chapter 6. The recommendations made reflect the different development patterns extant in each watershed, and are not restricted solely to the maintenance/improvement of stream water quality, i.e., aesthetic, open space and terrestrial habitat considerations also provide justifications for the recommended actions.

1.2 Overview of Nonpoint Source Pollution Problem

Historically, stormwater runoff systems in Suffolk County were designed to transport stormwater off paved surfaces and into stormwater drainage systems as efficiently as possible. Most of the stormwater and associated contaminants from coastal areas was discharged without treatment through drainage systems into marine surface waters. The *Long Island Comprehensive Waste Treatment Management Plan* (Long Island Regional Planning Board 1978) and *The Long Island Segment of the Nationwide Urban Runoff Program* (Long Island Regional Planning Board 1982a) clearly document that stormwater runoff (overland flow and stream flow) is the primary contributor of coliform contamination to marine surface waters in Suffolk County. In fact, over 90% of total and fecal coliform entering marine waters on a bay-wide basis in Suffolk County is a result of stormwater runoff. Although STP contributions of total and fecal coliform appear to be small on a bay-wide basis in Suffolk County, STP effluents may have significant impacts on local receiving water quality. It was concluded that on an areawide basis, the opportunities for preserving the quality of currently certified waters for the harvesting of shellfish far exceed those for improving the quality of conditionally certified or uncertified waters.

Recommendations made in the stormwater runoff chapter of the *Nonpoint Source Management Handbook*, (Long Island Regional Planning Board 1984) include both nonstructural and structural stormwater control measures, such as the use of permeable paving, stormwater retention ponds, in-line storage systems, biofiltration systems, natural depressions and cluster development to reduce the volume of stormwater runoff generated. The feasibility of implementing these techniques is obviously more favorable when dealing with new development situations, or in those circumstances where redevelopment and/or renewal is scheduled to occur. Site specific plans are required.

In this study of Neguntatogue and Beaverdam Creeks, an incremental approach is used to evaluate water quality and land use relationships. The study focuses, in depth, on a relatively small area, as compared to the region-wide studies, such as the 208 plan, and the ongoing Long Island Sound Study. Detailed data on land use, natural resources and other topics have been collected and are portrayed on large scale base maps. In addition to the parameters of water quality, such as coliform bacteria, nutrients, dissolved oxygen, etc., other measurements have been made including phytoplankton, sediment metals, benthos populations and bioassays. This has resulted in a more detailed prospectus on the *health* of the stream corridors. Many study recommendations are parcel specific, as opposed to regional or areawide. Of course, those recommendations that pertain to source control, i.e., the reduction of pollutant loads in urban stormwater runoff, are generic in nature.

Chapter Two

Selection of Urban and Semi-Rural Stream Corridors for Detailed Study

2.0 Introduction

This chapter summarizes land use, environmental resource information and water quality data availability for the 38 stream/river corridors tributary to Great South Bay. The basis for dividing the stream into two groups - urban stream corridors and semi-rural stream corridors - is discussed. The process for selecting the two detailed study areas indicative of urban and semi-rural watershed development scenarios is then described.

2.1 Classification of Great South Bay Stream Corridors

The criteria selected to characterize the 38 stream/river corridors listed in Table 2-1 from west to east that flow into the Great South Bay include the following parameters:

- size of stream/river and watershed
- mix of land uses within the watershed
- environmental resources
- availability of data/information on pollutant sources (point and non-point)
- availability of data on fresh and marine surface water quality

The following information for each of the 38 stream/river corridors was assembled:

- stream/river length
- predominant land uses
- environmental resources
- a determination of whether or not the stream was evaluated in the *Flow Augmentation Needs Study* (FANS) (Suffolk County Executive Office: Special Projects 1980)
- the designation of the stream/river corridor as either urban or semi-rural

This information is presented in Table 2-2 for the 23 stream/river corridors that were designated as urban streams: and in Table 2-3 for the 15 stream/river corridors classified as semi-rural.

The length of the stream/river corridors was characterized as either small, medium or large. To assure comparability of the selected urban and semi-rural stream/river corridors, length, stream flow and size of drainage basin were considered.

An evaluation of land use mix was conducted based on interpretation of 1984 (1″ = 400′ Town of Babylon) and 1987 (1″ = 1,000′ Town of Brookhaven and Town of Islip) aerial photographs and existing land use maps (Long Island Regional Planning Board 1982b). Low, medium and high density residential uses were identified, as well as commercial, marine commercial, industrial, recreational, institutional, agricultural and transportation and utilities. Further clarification within these categories was based on preliminary field inspection. These data provided the information necessary to categorize watersheds as being either urban or semi-rural. Urban areas typically exhibited medium to high density residential uses, a large number of commercial, industrial and institutional establishments, and limited areas in vacant, agricultural, or park and recreation uses. Semi-rural areas were characterized by medium to low density residential uses, and few commercial, industrial or institutional establishments. Natural, as opposed to man-modified shorelines, were predominant: and a portion of the watershed was vacant, used for agricultural purposes, or park and recreational facilities.

An inventory of environmental resources was also conducted for all urban and semi-rural streams utilizing the 1977 Natural Resources Inventory Maps (Long Island Regional Planning Board 1979), as well as the 1984 and 1987 aerials mentioned above. Characteristics of the stream/river corridors were identified. Extensive tidal and freshwater wetlands were noted, as well as the Designated Significant Coastal Fish and Wildlife Habitats (New York State Department of State 1987). Stream/rivers with USGS gauging stations were also listed (Spinnello et al. 1987).

Overall, the urban stream/river corridors lacked significant environmental resources, such as tidal wetlands, in addition to natural shoreline features. Rather, they were typified by structural alterations of the shoreline, such as bulkheads, wetland filling, and stormwater runoff drainage structures discharging to surface waters. The semi-rural stream/river corridors contained viable tidal and/or freshwater wetlands, many of which were Designated Significant Fish and Wildlife Habitats. Natural shoreline features predominate, as opposed to the structurally altered shorelines of urban stream/river corridors. Two streams, the Connetquot River and the Carmans River, are presently protected under the NYS Wild, Scenic and Recreational Rivers Act. Beaverdam Creek is currently being studied for potential inclusion in this program.

Stream/river corridors from the western boundary of the Town of Babylon east to the Connetquot River, were extensively evaluated in 1980 as part of the EPA funded FANS, which was conducted by the Suffolk County Dept. of Health Services. The freshwater component of these corridors was the primary focus of this study. Those stream/river corridors that were evaluated under FANS are noted in Tables 2-2 and 2-3.

Information in Long Island Regional Planning Board (1978; 1982a) relating to the stream/river corridors of Great South Bay was evaluated and compared with respect to point and nonpoint source loadings and marine and fresh water quality. Availability of other data/information on pollutant sources and water quality was ascertained through interviews with personnel from the USGS, NYSDEC, SUNY @ Stony Brook Marine Sciences Research Center, Suffolk County Dept. of Health Services, and the Towns of Babylon, Islip and Brookhaven.

TABLE 2-1

List of the 38 Stream/River Corridors that Flow into Great South Bay

Town of Babylon
Amityville Creek
Woods Creek
Great Neck Creek
Strong's Creek
Neguntatogue Creek
Santapogue Creek - West and East Branch
Carll's River
Sumpwams (Sampawams) Creek
Town of Islip
Skookwams Creek
Willets Creek
Trues Creek
Thompson's Creek
Cascade Lakes
Lawrence Creek
Watchogue Creek
Pentaquit Creek - West and East Branch
Awixa Creek
Orowoc Creek - West and East Branch
Champlin Creek
West Brook
Connetquot River
Brick Kiln Creek
Ludlows Creek/Indian Creek
Green Creek
Brown's River
Homan's Creek
Nankee Creek
Town of Brookhaven
Stillman Creek
Corey Creek
Tuthills Creek
Patchogue River
Swan River
Mud Creek
Abets Creek
Hedges Creek
Howell Creek
Beaverdam Creek
Carmans River
- Big Fish Creek
- Little Fish Creek
- Yaphank Creek
- Little Neck Creek

Another criteria that was considered for comparing these corridors included the question of multiple municipal jurisdiction over a watershed area, and hence, the need to consider different zoning codes and other regulations on land use within the watershed. Additional questions were directed to town agency staff for discussion regarding proposed development, rezoning plans, and availability of any local natural resource analyses or water quality monitoring programs conducted by the towns. This information was helpful in forecasting potential impacts in the stream/river corridors, as well as obtaining historical field data beneficial to understanding existing conditions in the stream/river corridors.

2.2 Rationale for Selection of Urban Stream Corridor

Comparative size was the first criteria that was evaluated. Short stream/river corridors were eliminated due to their small impact on the water quality of Great South Bay, as a result of low stream flow and limited drainage basin area. Long stream/river corridors were also eliminated based on the greater potential difficulty in identifying specific nonpoint pollutant sources from a larger drainage basin, as well as the demands a large stream/river corridor would impose on water quality monitoring and land use evaluation efforts. Table 2-4 lists nine urban stream/river corridors that were eliminated from further consideration because of size constraints.

Land use was then compared. Areas that included high density uses were classified as urban stream/river corridors; and those exhibiting low density uses and expansive areas of vacant land were classified as semi-rural stream/river corridors. Environmental resources were noted. Areas with natural shorelines, large areas of tidal or freshwater wetlands, or wooded lots were generally categorized as semi-rural stream/river corridors. There were no stream/river corridors flowing into Great South Bay that did not exhibit some degree of development. Therefore, no strictly rural, i.e., undisturbed,stream/river watersheds were found along the north shore of Great South Bay.

The *Long Island Comprehensive Waste Treatment Management Plan* (Long Island Regional Planning Board1978) and *The Long Island Segment of the Nationwide Urban Runoff Program* (Long Island Regional Planning Board 1982a) included modelling studies that were conducted to evaluate inputs from both point and nonpoint pollutant sources entering various embayments on Long Island, including Great South Bay. Stream characteristics and baseflow drainage area, as well as total coliform loadings by stream, were described. Stream/river corridors were also evaluated in detail as part of the FANS Milestone I Report (Suffolk County Executive Office: Special Projects 1980), and a water quality ranking was assigned to the 22 streams that were studied.

Based on the information outlined above, four additional urban streams were eliminated (Willets Creek, Awixa Creek, Green Creek and Corey Creek), leaving the 10 streams identified in Table 2-5 as the first round choices for additional consideration. Contacts were then made with New York State and Suffolk County governmental agencies and representatives from the Towns of Babylon, Islip and Brookhaven to gather further information/data and to receive feedback on the preliminary list of candidate study areas. As a result, Great Neck Creek, Strongs Creek and Santapogue Creek were eliminated from further consideration, with the remaining seven streams constituting the list of second round choices.

Additional detailed discussions were then held on the second round choices with the town representatives. Subjects that were discussed included: available water quality data; toxic pollutant data; detailed stormwater drainage data; municipal boundary locations; shellfish sanitary survey data; wetlands; marina development and boating activity; proposed development; natural vegetation analyses; USGS gauging station information; ground-water monitoring wells; rezoning plans; and town water quality monitoring programs.

After review of the opinions expressed and information/data available, Neguntatogue Creek was selected as the urban steam corridor for detailed study. This creek is located in the incorporated Village of Lindenhurst and the unincorporated hamlet of West Babylon, Town of Babylon.

According to the 1980 FANS study, Neguntatogue Creek has the worst freshwater quality ranking of the 22 streams entering western Great South Bay. The major land uses within this watershed include high and medium density residential, institutional, industrial and

TABLE 2-2
Great South Bay Urban Stream/River Corridor Descriptions

	Name	*Size*	*Land Use*	Environmental Resources	*FANS Study Conducted*
1	Amityville Creek	medium	med./high density residential; high school; apt. complex; Town park	stream-no. of Montauk Hwy.; lake/canal system; USGS gauging station	X
2	Woods Creek	medium	med./high density residential ; condo complexes; Town beach/recreation facility; marinas	extensive canal development; stream-no.of Montauk Hwy.; USGS gauging station	X
3	Great Neck Creek	medium	med./high density residential; restaurant	interconnecting canal system stream-no. of Montauk Hwy.; lake system	X
4	Strong's Creek	medium	med./high density residential; undeveloped Co. park; marina	extensive/interconnecting canal system; stream no. of Montauk Hwy.	X
5	Neguntatogue Creek	medium	med./high density residential; large marina facilities; restaurants	stream-no. of Montauk Hwy.; USGS gauging station	X
6	Santapogue Creek	medium/large	medium density residential; apt. complex; regional shopping center; Co. golf course; SWSD #3 plant	diverted stream-no. of Montauk Hwy.; east and west branches	X
7	Carll's River	large	low/med. density residential; Town park- active; LIRR train station; high school; State park	extensive stream/pond/lake system-no. of Montauk Hwy.; freshwater wetlands; culverts.	X
8	Sumpwams Creek (Sampawams Creek)	medium/large	medium density residential; LIRR yard; lumber-yard;; bus depot; marinas; major road system (Rte. 231)	extensive stream/pond/lake system-no. of Montauk Hwy.; USGS gauging station	X
9	Skookwams Creek	small	low/med. density residential		X
10	Willets Creek	medium	medium density residential; junior & senior high schools; shopping center		X
11	Cascade Lakes	small	low/med. density residential; Village marinas	extensive lake/stream system, culverts	X
12	Lawrence Creek	small	low/med. density residential; car dealership; commercial; restaurant	lake / pond system	X
13	Watchogue Creek	small (tributary to Pentataquit Creek)	low/med. density residential; restaurants; ferry terminals; boat repair; large Town marina; commercial		X
14	Penataquit Creek	medium/large	medium density residential; commercial; public school; restaurants; ferry terminals; regional shopping mall; boat repair	two branches; USGS gauging station	X
15	Awixa Creek	medium	low density residential; condo complex; apt. complex; shopping mall; cemetery		X
16	Orowoc Creek	large	low/med. density residential; restaurant; fishing industry; mobile home complex; school facility; some vacant land	extensive pond/lake/stream system; two branches; freshwater wetlands; NYSDOS designated significant fish & wildlife habitat	X
17	Green Creek	medium	low/med. density residential; public school; vacant land		
18	Homan's Creek	small	low/med. density residential; open space Town park; vacant land		
19	Corey Creek	medium	medium density residential;Town park; marinas; industrial; vacant land	pond/stream system	
20	Tuthills Creek	medium/large	commerical; condo/coops; some vacant land	extensive lake/pond/stream system; tidal wetlands	
21	Patchogue River	large	med./high density residential; industrial; town dock; Village STP facility; boat repair	extensive lake/pond/stream system	
22	Abets Creek	small	low/med. density residential; vacant land; marinas		
23	Hedges Creek	small	med./high density residential; vacant land	extensive tidal wetlands; lake/stream system	

TABLE 2-3
Great South Bay Semi-rural Stream/River Corridor Descriptions

	Name	*Size*	*Land Use*	*Environmental Resources*	*FANS Study Conducted*
1	Trues Creek	small	low/medium density residential; minimally developed Co. Park	tidal wetlands; NYSDOS designated significant fish & wildlife habitat	X
2	Thompson's Creek	small	low/medium density residential; Co. park; NYSDEC wetlands; condo development nearby	tidal wetlands; NYSDOS designated significant fish & wildlife habitat	X
3	Champlin Creek	medium/large	low/medium residential; Seatuck Preserve; private school; Town park/recreation center	lake system; tidal wetlands; USGS gauging stations; NYSDOS designated significant fish & wildlife habitat	X
4	West Brook	medium (tributary to Connetquot River)	open space - State park	arboretum-open space; freshwater wetlands; NYSDOS designated significant fish & wildlife habitat	X
5	Connetquot River	large	extensive open space-State park; college; marinas; restaurants	fish hatchery; freshwater wetlands; NYSDOS designated significant fish & wildlife habitat;NYS Wild, Scenic & Recreation River	X
6	Brick Kiln Creek	medium/small	medium density residential; NYSDEC wetlands; vacant land; Town park	two branches (all so.of Montauk Hwy.); 2-3 canals (man-made); all marine waters; NYSDOS designated significant fish & wildlife habitat	X
7	Ludlow /Indian Creek	medium	private school; vacant land; Co. park - golf course	tidal wetlands (all so.of Montauk Hwy.); all marine waters; NYSDOS designated significant fish & wildlife habitat	
8	Brown's Creek	large	open space - Co. park; restaurants; marinas	two branches; fresh/tidal wetlands	
9	Nankee Creek	small	vacant land; medium density residential	tidal wetlands; NYSDOS designated significant fish & wildlife habitat	
10	Stillman Creek	small	vacant land; low/medium density residential	tidal wetlands	
11	Swan River	medium	vacant land; low/medium density residential; Town park; marina; commercial	lake/stream system; tidal wetlands; USGS gauging station; NYSDOS designated significant fish & wildlife habitat	
12	Mud Creek	medium	vacant land; large marina; former duck farm; medium density residential	lake/stream system	
13	Howell Creek	small	Village golf course; low density residential		
14	Beaverdam Creek	medium	vacant land; low/medium density residential; agriculture	tidal wetlands; canals; USGS gauging station; NYSDOS designated significant fish & wildlife habitat	
15	Carmans River	large	vacant land; Federal/County parks - open space; commercial recreation; former duck farm	extensive tidal wetlands; NYSDOS designated significant fish & wildlife habitat; NYS Wild, Scenic & Recreational River	

TABLE 2-4

List of Great South Bay Urban Stream/River Corridors Eliminated from Consideration due to Size Limitations

Carlls River	large
Skookwams Creek	small
Cascade Lakes	small
Lawrence Creek	small
Orowoc Creek	large
Homan's Creek	small
Patchogue River	large
Abets Creek	small
Hedges Creek	small

TABLE 2-5

Great South Bay Urban Stream/River Corridors Considered for Case Study - First Round

Town of Babylon

- Amityville Creek*
- Woods Creek*
- Great Neck Creek
- Strongs Creek
- Neguntatogue Creek*
- Santapogue Creek
- Sumpwams (Sampawams) Creek*

Town of Islip

- Watchogue Creek*
- Penataquit Creek*

Town of Brookhaven

- Tuthills Creek*

*Indicates that the stream was included in the list of second round choices.

marine commercial (particularly, restaurants and marina facilities). It has the highest concentration of boats within the Town of Babylon; two major marina facilities are located at the mouth of the creek. A toxic survey conducted by NYSDEC in 1987 on this stream detected very high TBT (tributyltin) concentrations in bottom sediments (Charles deQuillfeldt pers. comm.).

2.3 Rationale for Selection of Semi-rural Stream Corridor

The same general process used to select the urban stream corridor case study area as outlined in section 2.2 was employed to designate the semi-rural stream corridor for detailed study. Table 2-6 lists the eight semi-rural stream corridors that were eliminated from further consideration because of size constraints. Land use, environmental resource information and water quality studies were reviewed with the result that six candidate streams remained on the first round list for additional review, as shown in Table 2-7. (West Brook was eliminated due to it being tributary to Connetquot River). Ludlow/Indian Creek was subsequently dropped from this list, with the remaining five streams advancing to second round choice status.

Further detailed discussions with town agency personnel on the second round choices identified in Table 2-7 were then held. Ultimately, final designation of the semi-rural stream corridor for case study analysis was awarded to Beaverdam Creek, which is located in the hamlet of Brookhaven, Town of Brookhaven.

The Beaverdam Creek watershed is primarily vacant with extensive tidal wetlands adjacent to the stream. Other major land uses include low to medium density residential and agriculture. It has been designated by NYSDOS as a Significant Fish and Wildlife Habitat and identified for study under the NYS Wild, Scenic and Recreational Rivers Act.

Beaverdam Creek is approximately the same length as the urban stream/river corridor selected for study - Neguntatogue Creek - and both watersheds are comparable in area. While alterations have been made to virtually all the 38 stream corridors leading into Great South Bay, the relative differences between these two streams (based on the degree of development within the watersheds) also led to their selection.

2.4 Case Study Area Base Maps

Sewage Works Studies Topographic Maps of the Five Western Towns, Suffolk County, NY., at a scale of 1″ = 200′ published in 1965, were utilized to determine the surface water drainage boundary for Neguntatogue and Beaverdam Creeks. From this preliminary boundary, final watershed boundaries were established by interpreting to the nearest road or tax map parcel boundary as shown on Suffolk County Real Property tax maps. Base maps at a scale of 1″ = 300′ that show tax map parcels and study area boundaries were then prepared for Neguntatogue and Beaverdam Creek watersheds. These base maps were used to portray existing land use, zoning, land available for development, environmental resources, and watershed analysis information as described in Chapter 3.

TABLE 2-6

Great South Bay Semi-rural Stream/River-Corridors Eliminated from Consideration due to Size Limitations

Trues Creek	small
Thompson's Creek	small
Connetquot River	large
Browns River	large
Nankee Creek	small
Stillman Creek	small
Howell Creek	small
Carmans River	large

TABLE 2-7

Great South Bay Semi-rural Stream/River Corridors Considered for Case Study - First Round

Town of Islip

- Champlin Creek*
- Brick Kiln Creek*
- Ludlow/Indian Creek

Town of Brookhaven

- Swan River*
- Mud Creek*
- Beaverdam Creek*

* Indicates that the stream was included in the list of second round choices.

Chapter Three

Land Use and Environmental Resource Analysis

3.0 Introduction

Existing land use, zoning, land available for development, environmental resources and watershed conditions within the Neguntatogue Creek and Beaverdam Creek watersheds are described in this chapter. Reference is made to the maps in the map appendix that display information pertaining to these topics. Estimates of existing population and projected population in the study areas are also included in this chapter along with analysis of those developmental constraints that are coupled with specific locations or resources found in the watersheds. Chapter 3 concludes with a summary table and discussion that compares the range of conditions found in the urban and semi-rural study areas.

3.1 Existing Land Use

3.1.1 Neguntatogue Creek

The Neguntatogue Creek study area is located within the Town of Babylon and the Incorporated Village of Lindenhurst and has a total area of 703.2 acres. About 75% of the study area is situated within the Village of Lindenhurst and the remaining area is located in the hamlet of West Babylon. The predominant land use is high density residential. Other land use categories found in the study area include medium density residential, commercial and marine commercial, industrial, institutional, open space and recreation, transportation, utilities, and vacant. The distribution of these land uses is shown in Table 3-1. The Existing Land Use map was prepared by interpretation of aerial photographs taken in 1980 with confirmation through site visits in 1989.

Residential land use in this area is described by two categories; medium and high density. The medium density residential use includes lands having between 1 and 5 dwelling units (D.U.) per acre. The high density residential use includes those lands with 5 or more D. U. per acre. There are 175.9 acres of medium density residential and 287.1 acres of high density residential uses in the Neguntatogue Creek study area.

Two types of commercial land uses are found in the Neguntatogue Creek study area; commercial and marine commercial. Commercial uses are concentrated along Montauk Highway, Wellwood Ave., East Hoffman Ave., and the northern boundary of the study area along the south side of Sunrise Highway. These uses primarily include neighborhood, retail and professional businesses for a total of 39 acres. The marine commercial uses, which total 56.7 acres, are primarily located adjacent to Neguntatogue Creek south of Montauk Highway with a few establishments located along Montauk Highway. Marinas and marine related facilities comprise these areas. A review of marina facilities is found in Table 3-2. The number of boat slips was determined for each facility from Boating Almanac Co., Inc. (1988) and 1980 aerial photographs. Other information in the table includes the availability of marine pumpout stations, fuel service and engine/bulk repair services. It should be noted that a substantial number of private docks are found along each side of the creek that moor boats, as well as the 1,277 commercial marina slips reported in Table 3-2.

TABLE 3-1

Land Use - Neguntatogue Creek Watershed

Land Use	*Acres*
Low Density Residential (≤ 1 D.U./acre)	0.0
Medium Density Residential (1 to 5 D.U./acre)	175.9
High Density Residential (≥ 5 D.U./acre)	287.1
Commercial	39.0
Marine Commercial	56.7
Industrial	17.9
Institutional	51.0
Open Space and Recreational	38.8
Agriculture	0.0
Vacant	18.2
Transportation	18.6
Recharge Basins	0.0
Utilities	0.0
Total	**703.2**

Industrial development is primarily located along East Hoffman Ave., particularly in the area south of the Long Island Railroad (LIRR) tracks between Smith Street and Delaware Avenue. It encompasses approximately 17.9 acres. A list of commercial and industrial uses is provided in Table 3-3.

There are 113 business-related establishments within the Neguntatogue Creek study area of which 89 are commercial uses and 24 are industrial uses. The following categories are the most prevalent commercial uses: general retail, automotive service station/repair, marina/repair, restaurant and deli/pizzeria. Manufacturing and bulk storage constitute the majority of industrial uses.

The entire Neguntatogue Creek study area is located within the Southwest Sewer District #3 (SWSD).To date, approximately 76% of the residences in the district are currently hooked up to this facility (J. Benedetto pers. comm.). Of the 113 commercial and industrial uses identified in this study, 72 have been hooked up to the SWSD to date. Presently, however, there is no mandatory requirement for connection. The sewer district went on line in 1981.

Lands in the institutional land use category are scattered throughout the study area. Included in this category are churches, schools, a post office, and fire department property. However, the largest insti-

TABLE 3-2
List of Marina Facilities on Neguntatogue Creek, Lindenhurst, New York

Marina name and address	*# of boat slips*	*pumpout station (Y or N)*	*fuel (Y or N)*	*engine/hull repair (Y or N)*
The Anchorage 401 East Shore Rd.	550	Yes	Yes	Yes
Karl Tank Shipyard 612 Roosevelt Ave.	10	No	No	Yes
Rutherig Marine Service 640 Roosevelt Ave.	30	No	No	Yes
Boatland 692 South Wellwood Ave.	100	Yes	Yes	Yes
Surfside 3 Marina 846 South Wellwood Ave.	400	Yes	Yes	Yes
Village of Lindenhurst Marina Foot of South Wellwood Ave.	62	No	No	No
Galley Restaurant 127 E.Montauk Hwy.	5*	No	No	No
Superboat Marina 694 Roosevelt Ave.	5**	No	No	No
Shore Gables Property Owners Assoc. 300 East Shore Rd.	25**	No	No	No
W & G Marine (and others) East Shore Rd. and Montauk Hwy.	90**	No	No	No
Total	**1277**	**3**	**3**	**5**

* transient only

** approximate number

tutional use is the Lindenhurst School District. Altogether, 51 acres are in this category.

There are three areas of open space and recreational lands in public ownership. They include two Village of Lindenhurst parks, and a Town of Babylon park and beach facility on Great South Bay known as Venetian Shores. Recreational facilities provided at this site include bay beach swimming, boat ramp and field sports. In addition, there are two private recreational land uses; one is a recreational center and the other is a small marina for a local homeowners association for a total of 38.8 acres within this category.

The transportation land use category includes parking lots and associated facilities of the LIRR, which bisects the area. There are 18.6 acres in this category. Traffic count information was obtained from New York State Dept. of Transportation for portions of Montauk Highway and Sunrise Highway which bisect the study area (D. Kost pers. comm.). For a 24 hr. period in May 1986, an average of 26,398 vehicles traveled east and west on Montauk Highway, Rte. 27A. For Sunrise Highway, Rte 27, during a day in May 1988, an average of 56,473 vehicles traveled east and west.

A few vacant parcels, which total 18.2 acres, are scattered throughout the study area. They consist of small individual lots located in developed subdivisions. There are no recharge basins found in the study area.

3.1.2 Beaverdam Creek

The Beaverdam Creek study area is located in the Town of Brookhaven in the hamlet of Brookhaven. It is primarily used for low and medium density residential purposes, and has an area of 1,314 acres. Other land use categories found here include commercial and marine commercial, industrial, institutional, open space and recreation, agriculture, transportation, recharge basin, and vacant. The distribution of land uses is shown in Table 3-4. The Existing Land Use map was prepared by using 1987 aerial photographs with confirmation through site visits in 1989.

There are two categories of residential land use in the study area: low density and medium density. Low density residential areas are those with one or fewer dwelling units per acre. Medium density residential areas have between one and five dwelling units per acre. There are 160.9 acres in low density residential and 295.6 acres in medium density residential uses in the Beaverdam Creek study area.

Commercial lands are limited in the Beaverdam Creek study area. Commercial land uses, such as neighborhood businesses, are concentrated primarily along Montauk Highway and total 16.2 acres. Two areas of marine commercial uses which total 6.1 acres are found along the creek south of Beaverdam Road . A review of these uses can be found in Table 3-5. It is estimated that less than 100 boats are accommodated in marina facilities along the creek.

A small industrial area of 4.5 acres is located on Arthur Ave., and is occupied by a light industry woodworking shop. A list of commercial and industrial uses is provided in Table 3-3. There are 40 establishments within the Beaverdam Creek study area of which 36 are commercial uses and four are industrial uses. The following categories were the most prevalent commercial uses:

- general retail
- automotive service station/repair
- restaurant
- deli/pizzeria
- professional office

Institutional uses are found on 66.1 acres within this study area. The Brookhaven School District owns the most property in this category. Churches, post offices and fire department properties are also included.

TABLE 3-3

Distribution of Commercial and Industrial Uses in the Neguntatogue Creek and Beaverdam Creek Study Areas

Commercial Uses	*# of establishments* Neguntatogue	Beaverdam	*Industrial Uses*	*# of establishments* Neguntatogue	Beaverdam
general retail	10	12	dairy	2	0
automotive			welding	1	1
service station/repair	19	3	manufacturing	8	0
sales	3	2	sheet metal	1	0
fleet storage yard/cab depot	1	0	cabinetry	1	1
marine			screen printing	1	0
marina/repair	10	2	research firm	1	0
sales	3	0	asphalt company	0	1
restaurant	15	4	cesspool service	0	1
deli/pizzeria	10	3	fuel oil storage	2	0
dry cleaner/laundromat	2	1	upholstery cleaning	1	0
hair salon	6	2	bulk storage	5	0
car wash	1	0	grinding service	1	0
doctor/dentist	1	2			
professional office	2	3			
motel	1	0			
funeral home	1	0			
photographic service	1	0			
landscaping/greenhouse	1	1			
farm stand	1	1			
pest control service	1	0			
Total # of establishments	**89**	**36**	**Total # of establishments**	24	**4**

TABLE 3-4

Land Use - Beaverdam Creek Watershed

Land Use	*Acres*
Low Density Residential (≤ 1 D.U./acre)	160.9
Medium Density Residential (1 to 5 D.U./acre)	295.6
High Density Residential (≥ 5 D.U./acre)	0.0
Commercial	16.2
Marine Commercial	6.1
Industrial	4.5
Institutional	66.1
Open Space and Recreational	22.8
Agriculture	44.6
Vacant	681.9
Transportation	12.4
Recharge Basins	2.9
Utilities	0.0
Total	**1314.0**

TABLE 3-5

List of Marina Facilities on Beaverdam Creek, Brookhaven, New York

Marina name and address	*# of boat slips*	*pumpout station (Y or N)*	*fuel (Y or N)*	*engine/ hull repair (Y or N)*
Beaver Dam Boat Basin, South Country Road	65	No	No	Yes
Marina, Fireplace Lane	28*	No	No	No
Total	**93**	**0**	**0**	**1**

* Approximate number

Approximately 45 acres of agricultural land are found in the study area. Almost one half of this acreage is located south of Beaverdam Road adjacent to Beaverdam Creek. A few smaller agricultural lots are scattered throughout other areas of the watershed.

The categories of transportation and recharge basin account for a small percentage of the land in the study area, and total 15.3 acres in size. Transportation facilities associated with the LIRR property parallel Montauk Highway, and four town-owned recharge basins are located south of the highway. Traffic count information was obtained from New York State Dept. of Transportation for portions of Montauk Highway and Sunrise Highway which bisect the study area (D. Kost pers. comm.). For a 24 hr. period in April 1988, an average of 14,826 vehicles traveled Montauk Highway, Rte. 27A, east and west. On Sunrise Highway, Rte. 27, 33,028 vehicles traveled east and west during a day in August 1988.

There are a few open space and recreation lands within this study area, which include a cemetery north of Montauk Highway, a neighborhood town park at the corner of South Country Road and Fireplace Road, New York State Dept. of Environmental Conservation wetlands located at the mouth of Beaverdam Creek, and a private tennis court facility in a nearby residential community. There is a total of 22.8 acres in this category.

A significant amount of vacant land - 681.9 acres - exists in the Beaverdam Creek study area. This acreage comprises over one half of the entire study area. South of Sunrise Highway and north of Montauk Highway, a large amount of vacant, old filed residential subdivision lots are found. Large parcels of vacant land are also located along Beaverdam Creek, south of South Country Road, and east of Edgar Ave.

3.2 Zoning

3.2.1 Neguntatogue Creek

The Zoning map reflects current zoning for the Neguntatogue Creek study area based on zoning code information from the Town of Babylon (1988) and the Village of Lindenhurst (1987).

Properties in the hamlet of West Babylon in the Town of Babylon comprise approximately one quarter of the study area. These properties are located east of Neguntatogue Creek and south of Montauk Highway, with another portion immediately south of Sunrise Highway.

The majority of the Town of Babylon properties in the hamlet of West Babylon is zoned residential. This zoning category is broken down into two classifications, the **B** and **C** districts, with minimum lot size requirements of 10,000 sq. ft. and 7,500 sq. ft., respectively. The remainder of the land zoned within the Town's jurisdiction is for neighborhood business. This commercial zoning category is broken down into two classifications, **E** and **Eb.** The difference between these categories is that **Eb** has greater setback requirements than **E.** These commercial zones are located along Montauk Highway and Sunrise Highway in addition to the area of the *dockominium* at the southern end of East Shore Road. The *dockominium* concept provides for private ownership of individual boat slips (usually a portion of the land adjacent to the slip) along with common areas owned together by all boat slip owners.

The remaining three quarters of the study area is within the Village of Lindenhurst, most of which is residentially zoned. In this area, the Village's residential zoning is divided into **B** and **C** districts. These have the same lot size requirement of 7,500 sq. ft., but with different setback requirements.

Several areas within the Village are zoned for neighborhood business. These areas are generally designated for retail trade establishments and are primarily located along Montauk Highway and Wellwood Ave.

There is also a section of the Village that is zoned for light industry. This section accounts for approximately 10% of the total study area and is located primarily along Hoffman Ave. and the LIRR corridor.

Neguntatogue Creek waterfront parcels south of Montauk Highway within the Village boundaries have been zoned for commercial and residential uses. North of Montauk Highway, properties adjacent to the stream are primarily in the Village's residential zoning category.

3.2.2 Beaverdam Creek

The Zoning map reflects current zoning for the Beaverdam Creek study area based on zoning code information from the Town of Brookhaven (1987). The two major zoning categories in this area are residential and commercial.

The vast majority of the land in this study area is zoned for residential use. This zoning category is divided into two classifications based on minimum lot size requirements. The **A2** residential category requires a minimum of 80,000 sq. ft. per lot. Areas in this zoning category are located between South Country Road and Bay Ave. south of Beaverdam Road and border both sides of Beaverdam Creek. The **A1** zoning category requires a minimum of 40,000 sq. ft. Lands in this category are located in the remainder, and majority, of the study area.

The commercial zoning district - **J2** or general business - occupies a relatively small portion of the study area, and is located primarily along Montauk Highway. There is also an area zoned commercial in the vicinity of the existing marina establishment located on the west side of the creek south of Beaverdam Road.

3.3 Land Available for Development

3.3.1 Neguntatogue Creek

Land available for development is derived from land use and zoning data. Zoning data were collected from the Town of Babylon (1988) and the Village of Lindenhurst (1987). Land use data were obtained from 1980 aerial photographs of Babylon, as well as field observations in 1989.

For purposes of this analysis, land available for development was divided into the following categories: vacant residential, private recreation and open space (development rights not ceded) and vacant non-residentially zoned land. Vacant non-residentially zoned old filed subdivision, vacant residential old filed subdivision, agriculture (development rights not ceded), and residential subdividable land were considered, but do not exist in the study area.

The amount of land available for development is found by determining the acreage in each category from parcel square footage on tax maps, and comparing same with the zoning code requirements. The number of building lots is calculated utilizing the yield per acre factors in Vol. II of the *Long Island Comprehensive Waste Treatment Management Plan* (Long Island Regional Planning Board 1978). This approach was utilized for the following categories: vacant residential and private recreation and open space. Vacant non-residentially zoned land includes both commercially and industrially zoned parcels. For this category, acreage was determined, but the number of lots available for development was not estimated.

As shown in Table 3-6, there is very little land available for development in the Neguntatogue Creek study area. Vacant residential lots include the majority of the land available for development. This category has the potential for 50 new residences and encompasses 13.7 acres of vacant land in the study area.

Private recreation and open space comprise less than one acre of land available for development.

The remaining vacant land falls into the vacant non-residentially zoned land category. This includes vacant land in commercially or industrially zoned areas of which 2.9 acres and 1.6 acres, respectively, are available for development.

Altogether, there are 19.1 acres of land available for development in the study area. This figure is less than 1% of the 703.2 acres comprising the Neguntatogue Creek watershed.

3.3.2 Beaverdam Creek

Land available for development is derived from land use and zoning data. Zoning data were collected from the Town of Brookhaven (1987). Land use data were obtained from 1987 aerial photographs of Brookhaven, as well as field observations in 1989. In the Beaverdam Creek study area, vacant land was found to be in either a commercial or residential zoning category.

For purposes of this analysis, land available for development was divided into the following categories: vacant residential, vacant residential old filed subdivision, agriculture (development rights not ceded), residential subdividable land, private recreation and open space (development rights not ceded), and vacant non-residentially zoned land. Vacant non-residentially zoned old filed subdivision land was considered, but none exists in the study area.

The amount of land available for development is found by determining the acreage in each category from parcel square footage on tax maps, and comparing same with the town zoning code requirements. The number of building lots is calculated utilizing the yield per acre factors in Vol. II of the *Long Island Comprehensive Waste Treatment Management Plan* (Long Island Regional Planning Board 1978). This approach was utilized for the following categories: vacant residential, agriculture, and private recreation and open space. For vacant residential old filed subdivisions, the land available for development was determined by estimating the actual number of vacant lots. The residential subdividable land category includes lots which currently have a residence on them, but which can be further subdivided according to existing zoning regulations. For this study, a parcel of land must have been two times the minimum lot size for its zoning designation to be considered in this category. Vacant non-residentially zoned land includes only commercially zoned parcels in this study area. For this category, acreage was determined, but the number of lots available for development was not estimated.

The vacant residential category has the greatest potential for new development in this study area as shown in Table 3-7. Comprised of 484.2 acres, this category has the potential for 292 one-acre zoned

TABLE 3-6
Land Available for Development - Neguntatogue Creek Watershed Area

	Village of Lindenhurst Zoning Categories						*Town of Babylon Zoning Categories*					
Land Use Categories	***B** Residential (7500 sq. ft.)*		***C** Residential (7500 sq. ft.)*		*Business*	*Industry*	***C** Residential (7500 sq. ft.)*		***E** Business*	***Eb** Business*	*TOTAL*	
	Acres	*Lots*	*Acres*	*Lots*	*Acres*	*Acres*	*Acres*	*Lots*	*Acres*	*Acres*	*Acres*	*Lots*
Vacant Residential	10.6	38	0.7	3			2.4	9			**13.7**	50
Vacant Residential Old Filed Subdivision												
Residential Subdividable Land												
Agriculture (Development Rights Not Ceded)												
Private Recreation and Open Space (Development Rights Not Ceded)	0.9	3									**0.9**	3
Vacant Non-Residentially Zoned Land					1.1	1.6			1.4	0.4	**4.5**	
Total	**11.5**	**41**	**0.7**	**3**	**1.1**	**1.6**	**2.4**	**9**	**1.4**	**0.4**	**19.1**	**53**

lots and 48 two-acre zoned lots. These vacant individual residentially zoned lots are located throughout the study area.

A second residential category is vacant residential old filed subdivision. The lands in this category are located in the northern portion of the study area, north and west of Montauk Highway and south of Sunrise Highway. Some of these old filed subdivision areas have been aggregated and replatted, however, the existing old filed sections comprise 195 acres of undeveloped land on which 589 lots are available for development. It is important to note that some of these lots are owned by the Town of Brookhaven, Suffolk County and New York State.

The residential subdividable land category includes lots which presently have a residence on them, but could be further subdivided according to existing zoning regulations. There are 36.9 acres within this category found scattered throughout the study area having a potential for 30 new residences.

Commercially zoned vacant lands fall into the vacant non-residentially zoned land category. Total acreage in this category is only 2.7 acres. The commercially zoned areas available for development are primarily located along Montauk Highway. There are no industrially zoned areas within the boundaries of the Beaverdam Creek study area.

Lands within the agriculture category are primarily located south of Beaverdam Road in addition to a section in the northeast corner of the study area. There is a total of 44.6 acres in this category, having the potential for 6 one-acre residential lots and 15 two-acre residential lots. There are 7.9 acres of private recreation and open space available for development.

Altogether, there are 771.3 acres of land available for development in the study area. This amounts to 59% of the 1,314 acres of land in the Beaverdam Creek watershed.

3.4 Population Analysis

3.4.1 Neguntatogue Creek

In 1980 the population of the Neguntatogue Creek study area was 10,417. (See Table 3-8.) This figure is based on an analysis of the 1980 U. S. Census blocks included within the watershed. Using population estimates supplied by the Long Island Lighting Company, the 1989 population of the Neguntatogue Creek study area is estimated at 10,764 (a 3.3% increase over 1980). This area has experienced slower growth than Suffolk County as a whole, where the population increased an estimated 8.2% from 1980 to 1989.

The saturation population (population when all available land is developed) in this study area was also determined. The Land Available for Development map was used to arrive at this potential future population figure. There were 53 lots available for residential development in the Neguntatogue Creek study area in 1989. Each of these vacant lots could potentially contain a housing unit. Therefore the number of vacant lots was multiplied by the number of persons per household for the study area (3.05) to arrive at an estimate of potential additional population of 162. This figure, when added to the 1989 population, yields a saturation population of 10,926 for the Neguntatogue Creek study area, which is a potential increase of only 1.5%.

3.4.2 Beaverdam Creek

The approach and data sources used to analyze population in the Neguntatogue Creek study area were also applied to the Beaverdam Creek watershed. Table 3-8 indicates that the 1980 population of the Beaverdam Creek watershed was 1,825. The 1989 population estimate is 1,847 (a 1.2% increase over the 1980 population). This area also experienced a growth rate slower than Suffolk County.

In 1989 there were 986 lots available for residential development in the Beaverdam Creek study area. At an estimated 2.91 persons per household in the hamlet of Brookhaven, the potential additional population in the area is 2,869. This figure, when added to the 1989 population, yields a saturation population for the Beaverdam Creek study area of 4,716. This represents a 155.3% increase over the 1989 population.

3.5 Environmental Resources

3.5.1 Neguntatogue Creek

SURFACE WATER - The total length of Neguntatogue Creek is 2.5 miles. (The length of the freshwater stream is 1.8 miles and 0.7 miles

Table 3-7

Land Available for Development - Beaverdam Creek Watershed Area

Land Use Categories	*Town of Brookhaven - Zoning Categories* *A1 Residential (40,000 sq. ft.)*		*A2 Residential (80,000 sq. ft.)*		*J2 Business*	*TOTAL*	
	Acres	*Lots*	*Acres*	*Lots*	*Acres*	*Acres*	*Lots*
Vacant Residential	364.7	292	119.5	48		**484.2**	**340**
Vacant Residential Old Filed Subdivision	195.0	589				**195.0**	**589**
Residential Subdividable Land	36.9	30				**36.9**	**30**
Agriculture (Development Rights Not Ceded)	7.5	6	37.1	15		**44.6**	**21**
Private Recreation and Open Space (Development Rights Not Ceded)	7.9	6				**7.9**	**6**
Vacant Non-Residentially Zoned Land					2.7	**2.7**	**—**
Total	**612.0**	**923**	**156.6**	**63**	**2.7**	**771.3**	**986**

Table 3-8

Population Summary

	1980 Population	*Est.1989 Population*	*1980-1989 Increase*	*Lots Available-For Residential Development.1989*	*Est.Persons Per Household 1989*	*Potential Additional Population*	*Saturation Population*	*Increase from 1989 to Saturation*
Neguntatogue Creek Study Area	10,417	10,764	3.3%	53	3.05	162	10,926	1.5%
Beaverdam Creek Study Area	1,825	1,847	1.2%	986	2.91	2,869	4,716	155.3%

is the marine segment length.) The surface water area of the Creek is approximately 29 acres.

TIDAL WETLANDS - Tidal wetland boundaries were identified through the use of the NYS Tidal Wetlands Act map series (Article 25 of the NYS Environmental Conservation Law) and interpretation of 1980 Keystone Aerial Surveys, Inc. aerial photographs (1" = 2000') for the Town of Babylon. Within the Neguntatogue Creek study area, no tidal wetlands exist due to extensive shoreline development. The area immediately adjacent to the creek is almost entirely bulkheaded.

FRESHWATER WETLANDS - Freshwater wetlands within the Neguntatogue Creek study area can generally be divided into two categories: emergent freshwater marsh and flooded deciduous marsh. The freshwater wetland boundaries were identified through the use of the NYS Freshwater Wetlands Act map series (Article 24 of the NYS Environmental Conservation Law) and interpretation of the 1980 aerial photographs utilized for the tidal wetland inventory noted above. Further details were provided by the U. S. Fish and Wildlife Service, Dept. of the Interior National Wetland Inventory Maps (1980). A total of approximately 16 acres exists within the Neguntatogue Creek watershed.

The emergent category of freshwater wetlands includes herbaceous plants that grow in standing water or waterlogged soils, particularly near the edges of freshwater bodies. The rich diversity of species found in these emergent freshwater wetland areas provides luxuriant foliage during the growing season setting it apart from its tidal counterparts. Various species of emergent vegetation include:

Cattails	*Typha spp.*
Common Reed	*Phragmites communis*
Joe Pye Weed	*Eupatorium purpureum*
Boneset	*Eupatorium perfoliatum*
Pond Lily	*Nymphaea odorata*
Swamp Loosetrife (Water Willow)	*Decodon verticillatus*
Sweet Pepperbush	*Clethra alnifolia*
Marsh St. Johnswart	*Hypericum virginica*
Bladderworts	*Utricolaria spp.*
Sedges	*Carex spp.*
Marsh Hibiscus (Swamp Rose)	*Hibiscus moscheutos*
Sundews	*Drosera spp.*
Arrowheads	*Sagittaria spp.*
Bulrushes	*Scirpus spp.*

Emergent wetlands can be found at Feller's Pond in the Village of Lindenhurst park east of Irmisch Ave. and south of Charles St., although the type and abundance of species is sparse in this area due to the development of the park itself. Emergent wetlands can also be found along the streambed of Neguntatogue Creek within the Village of Lindenhurst park east of Lincoln Ave.

Flooded deciduous freshwater wetlands are areas characterized by deciduous trees and shrubs growing in flooded or saturated soils or open freshwater. This type of wetland occurs along Neguntatogue

Creek at the Village of Lindenhurst Park east of Lincoln Ave. This park has been relatively undisturbed and has been retained in its natural state. Typical vegetation species in this category include:

Red Maple	*Acer rubrum*
Tupelo (Black Gum)	*Nyssa sylvatica*
Swamp Azalea	*Rhododendron viscosum*
Highbush Blueberry	*Vaccinium corymbosum*
Grey Birch	*Betula populifolia*
Black Willow	*Salix nigra*
Swamp Loosestrife (Water Willow)	*Decodon verticillatus*
Northern Bayberry	*Myrica pensylvanica*
Pitch Pine	*Pinus rigida*
White Pine	*Pinus strobus*
Sweet Pepperbush	*Clethra alnifolia*
Low Gallberry Holly (Ink Berry)	*Ilex glabia*
Cinnamon Fern	*Osmunda cinnamonea*
Spike Rushes	*Elochoris spp.*
Marsh Fern	*Thelypteris palustris*
Skunk Cabbage	*Spathyema foetida*
Sphagnum Moss	*Sphagnum spp.*
Speckled Alder	*Alnus rigosa*
Poison Ivy	*Rhus radicans*
Rushes	*Scirpus spp.*

UPLAND HABITATS - Four upland habitats were evaluated in this study, including forests, old fields, agricultural areas, and beach and maritime flora. However, the only upland habitat identified in the Neguntatogue Creek study area was beach and maritime flora.

BEACH AND MARITIME FLORA AREAS - Beachfront exists along the eastern side of the mouth of Neguntatogue Creek within the Town of Babylon Venetian Shores Park. Due to the development of the beach for recreational swimming, the extent of maritime flora in the area is limited. Typical vegetation species found in this sandy environment include:

Dusty Miller	*Artemisia stelleriana*
Field Rose	*Rosa carolina*
Beach Rose	*Rosa rugosa*
Seaside Goldenrod	*Solidago sempervirens*
American Beach Grass	*Ammophila breviligulata*
Beach Plum	*Prunus maritima*
Switch Grass	*Panicium virgatum*
Milkweed	*Asclepias spp.*
Beach Pea	*Lathyrus maritima*
Poison Ivy	*Toxicodendron radicans*
Smooth Sumac	*Rhus glabra*
Red Cedar	*Juniperus virginiana*
Northern Bayberry	*Myrica pensylvanica*

PRIME WILDLIFE AREAS - According to the NYSDEC (1976), the mouth of Neguntatogue Creek and all waters south of the study area within Great South Bay are considered Prime Wildlife Areas (PWAs).

SIGNIFICANT FISH AND WILDLIFE HABITATS - Great South Bay-West has been designated a *Significant Fish and Wildlife Habitat* by the NYSDOS (Executive Law of New York: Article 42; Sec. 910-920). (Neguntatogue Creek is tributary to this waterbody.) Final designation of this area was approved by NYSDOS on 15 March 1987 and subsequently by the U. S. Dept. of Commerce, NOAA on 22 April 1987. The Town of Babylon will be required to incorporate this designation into its State approved local coastal management plan. The following is excerpted from the NYSDOS Significant Fish and Wildlife Habitat Program narrative for Great South Bay-West (February, 1987):

> *This fish and wildlife habitat encompasses the entire western half of Great South Bay, which includes extensive areas of undeveloped salt marsh, tidal flats, dredge spoil islands, and a variety of open water areas.*
>
> *Great South Bay-West comprises approximately one-half of the largest protected, shallow, coastal bay area in New York State. A tremendous diversity of fish and wildlife species occur in this vast wetland area. Many species of migratory birds nest among the salt marshes and spoil islands in Great South Bay-West. In recent years, common terns (**T** - threatened species) have been confirmed nesting on Elder Island, Seganus Thatch, on a marsh island north of Gilgo Beach and on the southeastern end of Captree Island. An estimated 315 breeding pairs of common terns were observed in Great South Bay-West in 1985 and 340 pairs in 1984, with the largest concentrations in both years located on Seganus Thatch. Least terns (**E** - endangered species) nested on Nazeras Island (a large spoil island east of Cedar Island) in 1982 and 1983, but were absent in 1984 and 1985. Approximately 65 pairs of least terns nested there in 1983. Other bird species which nest in Great South Bay-West include Canada goose, herring gull, great black-backed gull, American oystercatcher, black skimmer, black duck, mallard, gadwall, willet, Virginia rail, clapper rail, marsh wren,sharp-tailed sparrow, and seaside sparrow. Several heronries have been located on islands within Great South Bay-West, including Gilgo Island, Sexton Island, Seganus Thatch, and an unnamed spoil island southwest of Nazeras Island. Species nesting in these areas include great egret, snowy egret, yellow-crowned night heron, black-crowned night heron, and glossy ibis, with the largest concentrations in 1984 on the island southwest of Nazeras Island. Several pairs of northern harrier (**T**) have been confirmed nesting in the northeastern end of Gilgo State Park, between Cedar Island and Oak Island. This locality is one of the largest areas of unditched salt marsh on Long Island; it is the only area in New York State where black rails (**SC** - species of special concern) have been regularly found, and is the only documented breeding location for soras on Long Island. Northern harriers and short-eared owls (**SC**) are common winter residents of the marshes in Great South Bay-West.*
>
> *The vast salt marshes, intertidal flats, and shallows in this area provide valuable feeding areas for birds throughout the year, including species nesting in the area and large concentrations of shorebirds during migration. In addition, Great South Bay-West is one of the most important waterfowl wintering areas (November - March) on Long Island, especially for brant and scaup. Nearly all of Great South Bay-West is open to the public for waterfowl hunting, and the area supports regionally significant hunting pressure.*
>
> *In addition to having significant bird concentrations, Great South Bay-West is an extremely productive area for marine finfish, shellfish, and other wildlife. Much of this productivity is directly attributable to the extensive salt marshes and tidal flats within the area. Great South Bay-West serves as a major nursery and feeding area (April - November, generally) for bluefish, winter flounder, summer flounder, kingfish, tautog, scup, blue claw crab, and forage fish species such as Atlantic silverside, mummichog, striped killifish, northern pipefish, and sticklebacks.*
>
> *The entire bay area is inhabited by hard clams, and the islands along the south shore support soft clams and ribbed mussels. Most of the bay waters are certified for shellfishing, resulting in a commercial and recreational harvest of statewide significance. Clam Pond, on the north shore of Fire Island, also contains a population of bay scallops which have been reintroduced to the area. Diamondback terrapin (**SC**) reside among the salt marsh islands in the bay, and utilize sandy areas along the south shore for egg-laying.*

CRITICAL ENVIRONMENTAL AREAS - Neguntatogue Creek is not considered a critical environmental area by Suffolk County under the New York State Environmental Review Act (SEQRA).

TYPICAL PLANT AND WILDLIFE POPULATIONS - A 1988 New York State mid-winter aerial waterfowl survey was conducted by NYSDEC. Neguntatogue Creek is included in the Great South Bay segment of this survey. The following species were identified for this segment:

Mallard	20
Black Duck	680
Mute Swan	59
Merganser	733
Canadian Goose	110
Coot	100
Total	1702

Breeding bird census information was provided in Andrle and Carroll, eds. (1988). Data was gathered in blocks covering 9.65 square miles. The Neguntatogue Creek study area was included in three blocks, which also covered areas outside the study area.Sixty-eight species of breeding birdswere found within the three blocks.

ENDANGERED AND THREATENED SPECIES OF FLORA AND FAUNA - Neguntatogue Creek study area contains no endangered species. However, Andrle and Carroll, eds. (1988) identifies two threatened species, the northern harrier (*Circus cyaneus*) and the common tern (*Sterna hirundo*), within the area surveyed, which includes the Neguntatogue Creek study area.

FISHERIES - Neguntatogue Creek supports little or no recreational fishing (Charles Guthrie pers. comm.). There is very little commercial fishing in Neguntatogue Creek as well. Commercial fishing, if it does occur, is most likely limited to seining for bait and some seasonal eeling (Chester Zawacki pers. comm.).

FRESH AND MARINE SURFACE WATER QUALITY - The NYSDEC has classified the marine and fresh waters of the State as to their potential best usage and has adopted water quality standards for each classification. Neguntatogue Creek has both tidal and fresh water sections. The tidal portion extends from the mouth of the creek to Montauk Highway, and has been classified as I. Best usage for waters in this class include secondary contact recreation and any other usage except for primary contact recreation and shellfishing for market purposes. Primary contact recreation includes activities where the human body may come in direct contact with raw water to the point of complete body submergence (swimming, diving, water skiing, skin diving, surfing). Secondary contact recreation includes activities where contact with water is minimal and where ingestion of water is not probable (includes, but is not limited to, fishing and boating). The NYSDEC has recommended upgrading the tidal portion from **I** to **SC** (Colbath Tucker pers. comm.). The best usage for **SC** waters is for fishing and fish propagation as well as primary and secondary contact recreation even though other factors may limit the use for that purpose.

The fresh water section of Neguntatogue Creek stretches from Montauk Highway to the creek's source near Sunrise Highway. In 1988, the classification of this portion was upgraded from **D** to **C**. Best usage for waters in class **C** include fishing, fish propagation, and all other uses except as a source of water supply for drinking, culinary, or food processing purposes.

According to NYSDEC, Neguntatogue Creek and surrounding waters at its mouth are presently closed to shellfishing activities due to unacceptable coliform levels.

The Suffolk County Dept. of Health Services (SCDHS) samples various bathing beach waters throughout the County for fecal coliform and total coliform to determine whether the bathing beach waters are suitable for swimming activities. The determination for closure is based on total and fecal coliform standards in Part 6 of the New York State Sanitary Code. According to SCDHS records, the Venetian Shores bathing beach facility, located on Great South Bay on the eastern side of the study area, was closed twice during the 1989 summer swimming season for the periods between June 16 through June 30 and July 11 through July 20 (Robert Nuzzi pers. comm.).

TIDAL CIRCULATION - Water circulation in the marine portion of Neguntatogue Creek, south of Montauk Highway, is dominated by tides, which have a mean range of 0.8 ft.

The impact of land use on Neguntatogue Creek is a function of land use type, location, pollution loading rate, and magnitude of tidal exchange. Contaminants are transported into the marine portions of the creek via freshwater stream flow north of Montauk Highway, stormwater runoff, and groundwater flow. Pollutants that dissolve in water, i.e., miscible pollutants, will eventually be removed from the marine portion by tidal action after obtaining a steady state concentration.

A parameter called *Pollution Susceptibility* has been used to quantify the relationship between discharge rates of conservative, miscible pollutants and resultant concentrations in tidal receiving waters (Nassau-Suffolk Regional Planning Board 1976). *Steady State Pollution Susceptibility* (SSPS) contour lines indicate the pollutant concentrations that would result from a discharge rate of one ton per day of a conservative pollutant at various shoreline locations after steady state conditions are attained. Lower SSPS values reflect more effective flushing action. The SSPS values calculated for the Great South Bay areas adjacent to both Neguntatogue and Beaverdam Creeks are greater than 1,000, making these areas very poorly flushed. As a consequence, pollutants and fine grained materials discharged to the creeks and Great South Bay would remain in the area for longer periods as compared to other portions of the bay closer to Fire Island Inlet that have low SSPS values. It is expected that the estuarine portions of both streams are also very poorly flushed, given restrictions in tidal circulation, low freshwater discharge and impacts of channel dredging activities.

DREDGING HISTORY - Extensive dredge and fill activities occurred along the marine portion of Neguntatogue Creek during the pre-1940 period. As a result, all tidal wetlands along the creek were obliterated.

According to the Suffolk County Planning Dept. (1985), Neguntatogue Creek was dredged by the Suffolk County Dept. of Public Works in 1977. Approximately 9,000 cubic yards of material was dredged and placed upland on nearby Indian Island County Park in Copiague.

SOILS - The majority of soil types in the study area consists of well-drained Riverhead and Haven soils with little slope. However, wet soils (Atsion Sand; Berryland mucky sand; Fill land - sandy) surrounding the creek present some constraints to development. A full discussion of soils, including their characteristics and suitability for development can befound in U. S. Dept. of Agriculture, Soil Conservation Service (1975).

3.5.2 Beaverdam Creek

SURFACE WATERS - The total length of Beaverdam Creek is 2.5 miles. (The length of the freshwater stream is 1.4 miles and 1.1 miles is the marine segment length.) The surface water area of the creek is approximately 25 acres.

TIDAL WETLANDS - Tidal wetlands boundaries have been identified on the Environmental Resources map according to the Tidal Wetlands Act (Article 25 of the NYS Environmental Conservation Law) and interpretation of 1987 Aerographic Corp. aerial photographs (1" = 1000') for the Town of Brookhaven. Approximateley 41 acres of tidal wetlands exist along Beaverdam Creek.

The intertidal marsh lies between the range of the daily tides. Its dominant vegetation is salt marsh cord grass (*Spartina alterniflora*), which is the most biologically productive plant of the wetland habitat. Just inland of the intertidal marsh is the high marsh, which is generally above the daily tidal flow and is regularly flooded only about 10 days per month. It is also flooded by storm tides. This area consists primarily of salt marsh hay (*Spartina patens*); as well as spike grass (*Distichlis spicata*); sedges (*Carex* spp.); with scattered bushes of marsh elder (*Iva frutescens*), groundsel tree (*Baccharis halimifolia*) and northern bayberry (*Myrica pensylvanica*). The NYSDEC tidal wetlands inventory also identified formerly connected tidal wetlands. These are areas that have been partially or entirely shut off by a roadway or impoundment from the normal tidal flow. These wetlands usually retain their marine plant community, although common reed (*Phragmites communis*) does infiltrate the area to some degree. Other vegetation species that have also been identified with the tidal wetland environment include:

Glasswort	*Salicornia spp.*
Black Grass	*Juncus gerardi*
Switch Grass	*Panium virgatum*
Sea Lavender	*Limonium carolinianum*
Salt Marsh Aster	*Aster tenuifolius*
Salt Marsh Gerardia	*Gerardia maritima*

Beaverdam Creek is surrounded by a significant wetland habitat. However, some residential and marine commercial development has occurred around the tidal portion of the creek, south of Beaverdam Road. The areas of intertidal marsh, high marsh, and formerly connected tidal wetlands are identified on the Environmental Resources map.

FRESHWATER WETLANDS - Freshwater wetlands within the Beaverdam Creek study areas can generally be divided into three categories: coastal freshwater marsh, emergent freshwater marsh, and flooded deciduous marsh. The freshwater wetlands boundaries were identified through the use of the NYS Freshwater Wetlands Act map series (Article 24 of the NYS Environmental Conservation Law) and checked through interpretation of the 1987 aerial photographs utilized for the tidal wetland inventory noted above. Further details were provided by the U.S. Fish and Wildlife Service, Dept. of the Interior National Wetland Inventory Maps (1980). A total of approximatly 121 acres exists within the Beaverdam Creek watershed.

Coastal freshwater marshes represent a type of transition zone where tidal wetland species are interspersed among the freshwater wetland vegetation. This type of wetland is highly productive. Vegetation species that are typically associated with this brackish/freshwater environment include:

Freshwater Cordgrass	*Spartina pectinata*
Cattails	*Typha spp.*
Sedges	*Carex spp.*
Marsh Fern	*Thelypteris palustris*
Marsh-pink	*Sabatia stellaris*
Canadian Burnett	*Sanguisorba canadensis*
Arrowhead	*Sagittaria latifolia*
Pickerelweed	*Pontederia cordata*
Groundsel Tree	*Baccharis halimifolia*
Marsh Elder	*Iva frustescens*
Salt Marsh Aster	*Aster tennifolius*
Salt Marsh Gerardia	*Gerardia maritima*
Button Bush	*Cephanlanthus occidentales*

In the Beaverdam Creek area, the coastal freshwater marshes are primarily located south of Beaverdam Road adjacent and inland to the tidal wetlands of Beaverdam Creek.

The second category of freshwater wetlands, called emergent, includes herbaceous plants that grow in standing water or waterlogged soils, particularly near the edges of freshwater bodies. The rich diversity of species found in these emergent freshwater wetland areas provides luxuriant foliage during the growing season setting it apart from its tidal counterparts. Various species of emergent vegetation include:

Cattails	*Typha spp.*
Common Reed	*Phragmites communis*
Joe Pye Weed	*Eupatorium purpureum*
Boneset	*Eupatorium perfoliatum*
Pond Lily	*Nymphaea odorata*
Swamp Loosetrife (Water Willow)	*Decodon verticillatus*
Sweet Pepperbush	*Clethra alnifolia*
Marsh St. Johnswart	*Hypericum virginica*
Bladderworts	*Ultricolaria spp.*
Sedges	*Carex spp.*
Marsh Hibiscus (Swamp Rose)	*Hibiscus moscheutos*
Sundews	*Drosera spp.*
Arrowheads	*Sagittaria spp.*
Bulrushes	*Scirpus spp.*

Emergent wetlands can be found in small pond-like areas along Beaverdam Creek north of Beaverdam Road.

The third category of freshwater wetlands is referred to as flooded deciduous. These are areas characterized by deciduous trees and shrubs growing in flooded or saturated soils or open water. This type of wetland is predominately found in a virtually undisturbed area north of Montauk Highway in the Beaverdam Creek study area, as well as areas upland of the emergent pond systems south of Montauk Highway. Typical vegetation species include:

Red Maple	*Acer rubrum*
Tupelo (Black Gum)	*Nyssa sylvatica*
Swamp Azalea	*Rhododendron viscosum*
Highbush Blueberry	*Vaccinium corymbosum*
Grey Birch	*Betula populifolia*
Black Willow	*Salix nigra*
Swamp Loosestrife (Water Willow)	*Decodon verticillatus*
Northern Bayberry	*Myrica pensylvanica*
Pitch Pine	*Pinus rigida*
White Pine	*Pinus strobus*
Sweet Pepperbush	*Clethra alnifolia*
Low Gallberry Holly (Ink Berry)	*Ilex glabia*
Cinnamon Fern	*Osmunda cinnamonea*
Spike Rushes	*Elochoris spp.*
Marsh Fern	*Thelypteris palustris*
Skunk Cabbage	*Spathyema foetida*
Sphagnum Moss	*Sphagnum spp.*
Speckled Alder	*Alnus rigosa*
Poison Ivy	*Rhus radicans*
Rushes	*Scirpus spp.*

UPLAND HABITATS - Four upland habitats were evaluated in this study, including forests, old fields, agricultural areas, and beach and maritime flora areas.

FORESTS - Two upland forest associations were identified within the Beaverdam Creek study area. The first, a pitch pine/oak association, represents a slightly dominated pitch pine over oak forest with an understory of such species as lowbush blueberry and scrub oak. This type of association is found north of Montauk Highway in the study area. Vegetation found within this association includes:

Pitch Pine	*Pinus rigida*
Black Pine	*Pinus Banksiana*
Red Cedar	*Juniperus virginiana*
Scrub Pine	*Pinus virginiana*
Scrub Oak	*Quercus ilicifolia*
White Oak	*Quercus alba*
Catbrier	*Smilax rotundifolia*
Black Oak	*Quercus velutina*
Scarlet Oak	*Quercus coccinea*
Mockernut Hickory	*Carya tomentosa*
Pignut Hickory	*Carya glabra*
Black Huckleberry	*Gayussacia baccata*
Lowbrush Blueberry	*Vaccinium vacillans*
Northern Bayberry	*Myrica pensylvanica*
Sweet Fern	*Comptonia peregrina*
Wintergreen	*Gaultheria spp.*
Trailing Arbutus	*Epigea repens*

The other upland forest identified in the Beaverdam Creek study area is a mixed deciduous forest. Dominant species types include oaks (*Quercus spp.*) and American beech (*Fagus grandifolia*).

Typical forest species found in this association include:

American Beech	*Fagus grandifolia*
White Oak	*Quercus alba*
Scarlet Oak	*Quercus coccinea*
Red Oak	*Quercus rubra*
Scrub Oak	*Quercus ilicifolia*
Chestnut Oak	*Quercus prinus*
Black Oak	*Quercus velutina*
Mockernut Hickory	*Carya tomentosa*
Pignut Hickory	*Carya glabra*
Flowering Dogwood	*Cornus florida*
Grey Birch	*Betula populifolia*
Red Cedar	*Juniperus virginiana*
Sassafras	*Sassafras albidum*
Red Maple	*Acer rubrum*
Lowbush Blueberry	*Vaccinium vacillans*
Coastal Highbush Blueberry	*Vaccinium caesariense*
Maple Leaf Viburnum	*Viburnum acerifolium*
American Holly	*Ilex opaca*
Catbrier	*Smilax rotundifolia*
Wintergreen	*Gaultheria spp.*

OLD FIELDS - Eleven sites, ranging from 3 to 65 acres in size, are identified on the Environmental Resources map as old field areas. Old fields provide open areas of grasses, shrubs and certain tree species, which are in the initial stages of forest succession. These areas are evidence of a natural revegetation process resulting from former clearing and/or farming practices. Typical species found at these sites include:

Goldenrod	*Solidago spp.*
Milkweed	*Asclepias syriaca*
Broom Sedge	*Andropogon virginicus*
Meadow-Grass	*Poa spp.*
Fescue	*Festuca spp.*
Ragweed	*Ambrosia artemisifolia*
Aster	*Aster pilosus*
Strawberry	*Fragaria virginiana*
Pokeweed	*Phytolacca americana*
Staghorn Sumac	*Rhus typhina*
Dwarf Sumac	*Rhus copallina*
Smooth Sumac	*Rhus glabra*
Meadow Rose	*Rosa blanda*
Blackberry	*Rubus spp.*
Sweet Fern	*Comptonia perigrina*
Raspberry	*Rubus idaeus*
Virginia Creeper	*Parthenocissus spp.*
Northern Bayberry	*Myrica pensylvanica*
Red Cedar	*Juniperus virginiana*
Wild Black Cherry	*Prunus serotina*
Pitch Pine	*Pinus rigida*
Gray Birch	*Betula populifolia*

AGRICULTURE - The Beaverdam Creek watershed contains four agricultural areas. One of the larger agricultural areas is located south of Beaverdam Road along the western bank of Beaverdam Creek.

BEACH AND MARITIME SHRUBLAND - A narrow beachfront exists along the Great South Bay. South of Beaverdam Road, Beaverdam Creek has extensive areas of maritime shrubland adjacent to the tidal wetland area of its banks. Most of these areas were former dredged spoil sites where a predominance of *Phragmites communis* is evident. Vegetation species identified in these sandy environments include:

Dusty Miller	*Artemisia stelleriana*
Field Rose	*Rosa carolina*
Beach Rose	*Rosa rugosa*
Seaside Goldenrod	*Solidago sempervirens*
American Beach Grass	*Ammophila breviligulata*
Beach Plum	*Prunus maritima*
Switch Grass	*Panicum virgatum*
Milkweed	*Asclepias spp.*
Beach Pea	*Lathyrus maritima*
Poison Ivy	*Rhus radicans*
Smooth Sumac	*Rhus glabra*
Red Cedar	*Juniperus virginiana*
Northern Bayberry	*Myrica pensylvanica*

PRIME WILDLIFE AREAS - Bellport Bay and Beaverdam Creek, with its associated wetlands, are considered Prime Wildlife Areas (PWAs) by the NYSDEC (1976). The Creek itself supports concentrations of salter brown trout. Marshes surrounding the mouth of the creek provide wintering areas for short-eared owls, marsh hawks, and rough-legged hawks. Wintering rafts of puddle ducks and geese can be found in Bellport Bay.

SIGNIFICANT FISH AND WILDLIFE HABITATS - Beaverdam Creek has been identified by the NYSDOS as a Significant Fish and Wildlife Habitat (Executive Law of New York: Article 42: Sec. 910-920). Final designation of this area was approved by NYSDOS on 15 March 1987 and subsequently by the U. S. Dept. of Commerce, NOAA on 22 April 1987. The Town of Brookhaven will be required to incorporate this designation into its State approved local coastal management plan.

The significant fish and wildlife habitat area encompasses the tidal portion of Beaverdam Creek, up to Beaverdam Road bridge, including the creek channel and approximately 130 acres of adjoining tidal wetlands. The NYSDEC owns approximately 16 acres of tidal wetlands near the mouth of Beaverdam Creek. Portions of the area have been disturbed by residential development and construction of boat docking facilities. The following discussion is excerpted from the NYSDOS Significant Fish and Wildlife Habitat Program narrative for Beaverdam Creek (February 1987):

> *Beaverdam Creek is a relatively undeveloped tidal stream channel, bordered by a substantial area of productive marshland. Habitats such as this are relatively rare in Suffolk County, as a result of extensive residential development and marina development along the south shore. Beaverdam Creek is one of only about 5 streams on Long Island which support significant concentrations of sea-run brown trout. During the fall (September - November), this fisheries resource supports a recreational fishery of county-level significance. However, no formal public access to the area has been developed. No unusual concentrations of any wildlife species are known to occur in the area. The tidal marshes adjoining Beaverdam Creek contribute significantly to the biological productivity of Bellport Bay.*

In addition, the NYSDOS has designated Great South Bay-East as a Significant Fish and Wildlife Habitat. (Beaverdam Creek is tributary to this water body.) The following is an excerpt from the NYS Significant Fish and Wildlife Habitat Program narrative for Great South Bay-East (February 1987):

> *This fish and wildlife habitat is an approximate 32,000 acre area, generally defined by the mean high water elevation on the north and south sides (exclusive of federal lands), by the Brookhaven town line to the west, and by the Smith Point bridge over Narrow Bay to the east. Great South Bay-East comprises approximately one-half of the largest protected, shallow, coastal bay area in New York State. This broad expanse of open water is highly productive, and supports a tremendous diversity of fish and wildlife species. Many species of migratory birds which typically occur in coastal habitats are found nesting or feeding in the remaining natural areas along the north and south shores of Great South Bay-East. These include green-backed heron, black-crowned night heron, snowy egret, American bittern, Canada goose, mallard, black duck, gadwall, northern harrier (**T**-threatened species), osprey (**T**), least tern (**E**-endangered species), herring blackbird, sharp-tailed sparrow, and seaside sparrow. Great South Bay-East is also one of the most important waterfowl wintering areas (November - March) on Long Island, especially for diving ducks, which feed on eelgrass, invertebrates, and small fish. Nearly all of Great South Bay-East is open to the public for waterfowl hunting, but*

due to the limited amount of emergent wetlands within the bay, hunting pressure is of only local significance.

In addition to having significant bird concentrations, Great South Bay-East is an extremely productive area for marine finfish, shellfish, and other wildlife. Much of this productivity is directly attributable to the salt marshes and tidal flats found throughout Great South Bay. Great South Bay-East serves as a major spawning, nursery, and foraging area (April - November, generally) for winter flounder, kingfish, bluefish, blue claw crab, and forage fish species, such as Atlantic silverside, striped killifish, mummichog, northern pipefish, and sticklebacks. A total of 56 fish species were collected during an intensive survey of Great South Bay in 1981. As a result of the abundant fisheries resources in this area, Great South Bay-East receives heavy recreational fishing pressure, of statewide significance. Winter flounder predominates the sportfishery catch in Great South Bay-East, but portions of the habitat are regarded as ***hotspots*** *for weakfish, scup, and summer flounder. A commercial fishery for Atlantic silverside and white perch has been established in the Bellport Bay area. The entire Great South Bay-East area is inhabited by concentrations of hard clams along with local concentrations of American oyster. Most of the bay waters are certified for shellfishing, resulting in a commercial and recreational harvest of statewide significance.*

CRITICAL ENVIRONMENTAL AREA - Under a recent amendment to the Suffolk County Charter (S.C. Resolution #660-87), the County has designated sensitive land areas within Suffolk County as critical areas of environmental concern so as to ensure that any actions (construction or other activities undertaken by, funded by, or requiring permits from any agency) taking place within or contiguous to these areas will be considered as Type I actions under the New York State Environmental Review Act (SEQRA). This amendment will require the completion of a full environmental assessment form for each action proposed within or adjacent to these designated areas. This process may possibly provide a greater review of environmental impacts which could result from such actions.

The entire Beaverdam Creek study area is included in the *Coastal Zone Area South* Critical Environmental Area.

TYPICAL PLANT AND WILDLIFE POPULATIONS - A 1988 New York State mid-winter aerial waterfowl survey was conducted by NYSDEC. Beaverdam Creek is included in the Carmans River segment of the survey. The following species were identified in this segment:

Mallard	75
Black Duck	180
Mute Swan	6
Canvas Back	25
Canadian Goose	130
Total	**416**

Breeding bird census information was provided in Andrle and Carroll, eds. (1988). Data was gathered in blocks covering 9.65 square miles. The Beaverdam Creek study area was included in two blocks, which also covered areas outside the study area. Ninety-eight species of breeding birds were found within the two blocks.

On a 25 July 1987 field trip conducted in the upper reaches (Montauk Hwy. to Sunrise Hwy.) of Beaverdam Creek by Karen Blumer and Jim Fuchs, 41 species of plants were identified. The following eight of these species were considered uncommon to the area:

Spreading dogbane	*Apocynum androsaemifolium*
Orchid	*Habeneria spp.*
White-fringed orchid	*Habenaria blephariglottis*
Inkberry	*Ilex glabra*
Canada rush	*Juncus canadensis*
Turk's cap lilly	*Lilium superbum*
Bur-reed	*Sparganium androcladium*
Lance-leaved violet	*Viola lanceolata*

During field trips conducted by Karen Rowley on 14 June and 4 July 1987, 21 species of birds were identified in the Beaverdam Creek study area.

ENDANGERED AND THREATENED SPECIES OF FLORA AND FAUNA - According to the NYSDEC, no known endangered species were identified in the Beaverdam Creek study area. However, two threatened species, the osprey (*Pandion haliaetus*) and northern harrier (*Circus cyaneus*), have been identified in the area surveyed in Andrle and Carroll, eds. (1988), which included the Beaverdam Creek study area. In addition, a threatened species of mud turtle (*Kinosternon subrubrum*) can be found in the Carmans River, which is in close proximity to Beaverdam Creek. Beaverdam Creek has not been investigated for the existence of the mud turtle, but because it provides a habitat similar to that of the Carmans River, Beaverdam Creek may be a possible habitat for this species.

FISHERIES - Beaverdam Creek is stocked annually with 3,000 fingerling brown trout. Although recreational fishing does occur, no published information on recreational fishing activity in Beaverdam Creek is available (Charles Guthrie pers. comm.).

The mouth of Beaverdam Creek and the waters of Bellport Bay are used for limited commercial bait fishing. This may include seining for Atlantic silverside and mummichog, as well as seasonal eel fishing (Chester Zawacki pers. comm.).

FRESH AND MARINE SURFACE WATER QUALITY - The NYSDEC has classified the marine and fresh waters of the State as to their potential best usage and has adopted water quality standards for each classification. Beaverdam Creek is divided into tidal and fresh portions. The tidal portion, which occurs between the mouth of the creek and Beaverdam Road, is classified **SC**. Best usage of waters in this class include fishing, fish propagation, primary and secondary contact recreation. Primary contact recreation includes activities where the human body may come in direct contact with raw water to the point of complete body submergence (swimming, diving, water skiing, skin diving, surfing). Secondary contact recreation includes activities where contact with water is minimal and where ingestion of water is not probable (includes but is not limited to fishing and boating).

The fresh water portion of the creek extends from Beaverdam Road to its source near Sunrise Highway. This section is classified **CTS** which designates it as a trout spawning area. These waters are suitable for fishing and fish propagation, as well as primary and secondary contact recreation, even though other factors may limit the use for that purpose.

There have been petitions to change both the freshwater and tidal section classifications (Colbath Tucker pers. comm.).

According to NYSDEC, Beaverdam Creek and the surrounding waters at its mouth are presently closed to shellfishing due to unacceptable coliform levels.

NYS WILD, SCENIC AND RECREATIONAL RIVERS PROGRAM - Beaverdam Creek is under a five-year state building moratorium pending a decision whether to include it in the NYS Wild, Scenic and Recreational Rivers Program. In July of 1988, Beaverdam Creek was put into the category of a **study river**. The moratorium will last until the study is completed, or the five-year period ends. In the meantime, all development allowed in the study area must conform with the scenic category of the regulations, and no variances will be entertained. (George Profus pers. comm.)

TIDAL CIRCULATION - Water circulation in the marine portion of Beaverdam Creek, south of Beaverdam Road, is dominated by tides, which have a mean range of 0.7 ft.

The impact of land use on Beaverdam Creek is a function of land use type, location, pollutant loading rate, and magnitude of tidal exchange. Contaminants are transported into the marine portions of the creek via freshwater stream flow north of Beaverdam Road, stormwater runoff, and groundwater flow. (Mosquito control activities also introduce contaminants directly into the wetland/estuary system.) Some dissolved and particulate pollutants may be transformed and/or trapped in the tidal wetlands that fringe the stream shoreline. Pollutants that dissolve in water, i.e., miscible pollutants, will eventually be removed from the marine portion of the stream by tidal action after obtaining a steady state concentration.

For discussion on Pollution Susceptibility see Section 3.5.1 - Tidal Circulation.

DREDGING HISTORY - Old aerial photographs (circa 1930) indicate that the marine portion of Beaverdam Creek was dredged with the result that the creek channel was shortened and widened. Bulkheaded canals were evident in the early 1960s adjacent to the west side of the Creek near its mouth on Great South Bay.

Beaverdam Creek was dredged by the Suffolk County Dept. of Public Works in 1965, according to the Suffolk County Planning Dept. (1985). Approximately 163,100 cubic yards of material were dredged and placed upland during this dredging project.

SOILS - Most of the soils found in the Beaverdam Creek study area are deep, well-drained, and moderately coarse textured. Soils presenting the most constraints to development are those on moderately steep slopes (Riverhead sandy loam, Riverhead-Haven soils, Plymouth loamy sand) and wet soils associated with the streambed (Muck, Tidal marsh, Sudbury sandy loam, Wareham loamy sand). A full discussion of soils, including their characteristics, suitability, and constraints to development can be found in U. S. Dept. of Agriculture, Soil Conservation Service (1975).

3.6 Watershed Analysis

3.6.1 Neguntatogue Creek

A watershed can be defined as a hydrologic system in which all of the land and surface waters drain to a single receiving water body (i.e., lake, bay, ocean, etc.). It is a region or land area bounded by a ridge or connection between topographic high points. The Neguntatogue Creek watershed drains into Neguntatogue Creek and is delineated by the surface water drainage boundary outlined on the Watershed Analysis map. The direction of surface water flow is generally toward the streambed via roadways and overland flow.

Watersheds, with their various land uses and activities, have a major influence on the quality and quantity of fresh, surface and ground waters. Drainage characteristics provide a means of linking the impacts of land uses and activities on marine water quality. Pollutants from watersheds directly influence the biota, environmental productivity, and commercial/economic value of coastal waters.

The direction of surface water flow and the location of storm drains, storm pipes, manholes, recharge basins and drainage ditches have also been identified on the Watershed Analysis map. Detailed information of storm drains, storm pipes and manholes for this study area was obtained from the Town of Babylon Highway Dept. and the Village of Lindenhurst Dept. of Public Works. As evidenced on the map, there is an extensive network of storm drains and pipes in the study area, 27 of which lead directly into Neguntatogue Creek.

The slopes found within the study area are almost entirely gradual, from 0% to 10%, where mostly outwash deposits, as well as marsh deposits, adjacent to the stream bed and Great South Bay, can be found. Furthermore, there are no major swales in the study area.

In evaluating the topographic elevation of the land surface and the 5 ft. ground-water contour line, areas adjacent to the coast that exhibit seasonal high ground-water table levels less than 5 ft. from the land surface have been identified on the Watershed Analysis map. It is important to locate these areas where cesspools are likely not to function properly, and water and sewer pipes must be specially sealed to prevent freezing when located at depths of less than 3 ft.

In the Neguntatogue Creek study area, depth to seasonal high water is less than 5 ft. within approximately 500 ft. on either side of the creek north of Montauk Highway and encompasses most of the study area south of Montauk Highway. See section 3.6.2 for a discussion of Suffolk County Dept. of Health Services standards for location and construction of domestic sewage disposal systems.

According to U. S. Dept. of Agriculture, Soil Conservation Service (1975), the following soils in the study area have seasonal high ground water less than 2 ft. from the surface: Atison sand and Berryland mucky sand. These soils are located primarily in the Neguntatogue Creek streambed.

It should be noted that presently there are no point discharges entering Neguntatogue Creek (Philip Barbato pers. comm.). However, prior to their recent connections with the Southwest Sewer District (SWSD) #3 over the last few years, three establishments were issued *State Pollutant Discharge Elimination System* (SPDES) permits, which authorized the discharge of effluent either to ground water or surface water, i.e., Neguntatogue Creek. One major discharger to Neguntatogue Creek was a dairy operation. Other industrial discharges included a cooling discharge from a condenser manufacturer and a discharge from a screen printing operation.

Part of the impact of the SWSD #3 that is being monitored by the SCDHS is its effect on ground-water levels, since the SWSD #3 has an Atlantic Ocean outfall. Recently, streams in Nassau County have experienced decreases in ground-water flow. This has been the affect of ground-water withdrawals that exceed recharge to local streambeds, which result in a decreased water table level in these areas.

The Suffolk County *Flow Augmentation Needs Study* (FANS) was conducted to identify actions for mitigating impacts from declines in streamflow attributable to sewering within the SWSD # 3, when and if these declines occur. The *Suffolk County FANS Milestone III* report (Suffolk County Department of Public Works 1990) will provide guidance to ensure that sufficient flow is maintained in certain sensitive areas to preserve wetland health and the aesthetic and recreational values of pond sites. Neguntatogue Creek was one of 12 streams selected for potential flow augmentation measures.

To date, lowered ground-water elevations, streamflow declines, and stream shortenings have not been evident (Suffolk County Department of Public Works 1990). Therefore, a set of *triggering mechanisms* was developed to indicate if and when augmentation is necessary. The key parameter that will be measured is the average depth to ground water in selected test wells. In addition, ecological monitoring will identify wetland vegetation changes.

Neguntatogue Creek, specifically Feller's Pond, was recommended for ground water pumping - direct discharge. This alternative recommends that wells be constructed to pump ground water to a discharge site along the stream when necessary.

The Draft Environmental Impact Statement for the *Suffolk County FANS Milestone III* report examined nine alternatives. Other alternatives included: reducing water consumption; employing a restrictive barrier within the aquifer; restricting ocean flow into Great South Bay; among others. The construction of additional stormwater drainage facilities was also considered, however, it was concluded that such additional stormwater contributions would provide insignificant flow volumes, and would involve significant economic and construction related impacts (Suffolk County Department of Public Works 1990).

The 100-year tidal floodplain boundary delineates the area which would be inundated by a 100-year flood; a flood of the magnitude of a 100-year flood is likely to occur on the average of once every 100 years. *Flood Insurance Rate Maps* (FIRMs) prepared by the Federal Emergency Management Agency provided the 100-year tidal floodplain boundary that includes both a **V** and **A** Zone. This area is illustrated on the Watershed Analysis map. The **V** Zone is that area immediately adjacent to Great South Bay which extends landward to the point where the 100-year flood depth is insufficient to support a 3 ft. breaking wave. The **A** Zone is located landward of the **V** Zone to the inland boundary of the 100-year flood. A significant portion of the study area south of Montauk Highway is located within the **A** Zone, in addition to an area adjacent to the stream immediately north of Montauk Highway to Texas Street. The base flood elevation in the study area is 9 ft. above *National Geodetic Vertical Datum* (NGVD) in the **V** Zone, where structures have to be elevated on piles or piers to these heights or greater; and ranges from 7-8 ft., in the **A** Zone, where the first floor and basement must be elevated over 7 or 8 ft. above NGVD.

It was estimated that there were 452 residences in the **A** and **V** Zones of the Neguntatogue Creek study area as of 1980 (Long Island Regional Planning Board 1984).

The Neguntatogue Creek watershed is located in Hydrogeologic Zone **VII**. This zone is characterized as a generally shallow and horizontal ground-water flow system. This flow system discharges to streams and Great South Bay, and hence will affect their quality.

Article 6 of the Suffolk County Sanitary Code, Realty Subdivisions and Developments, empowers the Suffolk County Board of Health to control the density of on-site systems in new developments. The minimum lot size requirement for new homes with septic systems in Zone **VII** is 20,000 sq. ft. However, this area is within the SWSD #3, which enables connection to a sewage treatment plant in lieu of installing a septic system.

The ground-water table contour lines, which delineate the water table altitude above NGVD, are shown on the Watershed Analysis Map in 5 ft. intervals (Suffolk County Dept. of Health Services 1988). The water table altitude in the Neguntatogue Creek study area ranges from the NGVD along the southern portion, near Great South Bay, to approximately 25 ft. above NGVD along the northern portion of the study area near Sunrise Highway.

According to Pluhowski and Kantrowitz (1964), ground-water flow in the Upper Glacial aquifer is predominately horizontal and perpendicular to the lines of equal water-table altitude. Ground water, which originates from the ground-water divide north of the study area, moves in a southerly direction. Ground-water discharges, in this study area, move toward Neguntatogue Creek both laterally and from below. Below this upper zone, the flow is nearly parallel to the stream. Ground-water flow to the creek begins at that point where the water table first intersects the stream channel bottom. For Neguntatogue Creek, this occurs in the vicinity of Sunrise Highway. Ground water not discharged into the creek moves southward where it eventually discharges to the tidal reaches of the creek or Great South Bay or the Atlantic Ocean.

The Upper Glacial aquifer is recharged by precipitation and, to a lesser degree, by upward leakage from the deeper Magothy aquifer in this area. The thickness of the Upper Glacial aquifer in the Neguntatogue Creek study area is about 75 ft. with a depth to water table in this aquifer ranging from 0 to 15 ft. depending on the land surface elevation. According to the study by Pluhowski and Kantrowitz (1964), little or no upward flow reaches Champlin Creek in Islip from deep within the water-table (Upper Glacial) aquifer. This creek is equidistant from both Neguntatogue and Beaverdam Creeks.

According to the same report, it was noted that a major source of ground-water contamination in 1961 stemmed from increased use of synthetic detergents in commercial and home laundries. The report went on to say that,

> *...in the face of increased urbanization and water use, the ground-water reservoir must be protected from excessive pollution by sewage disposal and contamination by salt-water encroachment. It appears likely that in the future an extensive sanitary sewer system will be constructed to eliminate pollution.*

The SWSD #3 went on line in 1981 and provides sewer service to this area.

Virtually the entire Neguntatogue Creek study area is serviced by public water provided by Suffolk County Water Authority. According to the SCDHS (Martin Trent pers. comm.), one public water supply well is located west of the Neguntatogue Creek study area, north of Hoffman Ave. There are also two water level test sites south of Montauk Highway on either side of the creek. It should be noted that although the public water supply well does not exceed State health drinking water standards, it does exceed the State Health Department's standard for iron. This is common in much of Long Island's drinking water. The iron standard is applied for aesthetic reasons, rather than for reasons of protecting public health.

The SCDHS (James Pim pers. comm.) has inventoried potential toxic waste sites throughout Suffolk County in cooperation with the CLEARS (Cornell Laboratory for Environmental Applications of Remote Sensing) program. One such site exists just east of the Neguntatogue Creek study area, south of Sunrise Highway. This 2-3 acre area is the site of a former landfill, which has now been residentially developed.

3.6.2 Beaverdam Creek

The Beaverdam Creek watershed is delineated by the surface water drainage boundary outlined on the Beaverdam Creek Watershed Analysis map. The direction of surface water is generally toward the streambed, via roadways and overland flow.

The direction of surface water flow and the location of storm drains, storm pipes, manholes, recharge basins and drainage ditches have also been identified on the Watershed Analysis map. This information was obtained through field investigations. Unfortunately, detailed mapping, particularly of storm pipes, was not available from Town of Brookhaven records. As evidenced on the map, there are 14 storm drains/pipes that discharge directly into Beaverdam Creek. Twelve of these drains are located in the residential subdivision along the southwestern portion of the creek near its mouth.

The slopes found within the study area are generally gradual, from 0% to 10%, where outwash deposits and marsh deposits adjacent to the streambed and Great South Bay are found. There are areas with slopes greater than 10% along a ridge line to the west of the creek. Associated with this area are swales that primarily slope in the direction of the streambed. Roadways adjacent to major swales may increase the volume of stormwater flow into nearby surface waters.

Areas have been identified on the Watershed Analysis map that exhibit seasonal high ground-water table levels less than 5 ft. from the land surface. It is important to locate these areas where cesspools are likely not to function properly and water and sewer pipes must be specially sealed to prevent freezing when located at depths of less than 3 ft. According to Suffolk County Dept. of Health Services (SCDHS) *Standards for Approval of Plans and Construction for Subsurface Sewage Disposal Systems for Single Family Residences*, ground-water elevations shall be measured at mean high tide in areas subject to tidal action. Furthermore, a minimum distance of 75 ft. for septic tanks, and 100 ft. for leaching pools, should be maintained from any surface waters. For areas where the depth to ground water is less than 8 ft., the SCDHS requires that it be consulted regarding leaching system construction.

In addition, SCDHS (Robert Villa pers. comm.) recommends a 5 ft. minimum depth to ground water from the bottom of the leaching pool for single and separate family residences and an 8 ft. minimum depth to ground water for new residential subdivision development.

In the Beaverdam Creek study area, depth to seasonal high water is less than 5 ft. within approximately 400 feet on either side of the creek and encompasses greater than 50% of the study area south of Beaverdam Road.

According to the *Soil Survey of Suffolk County, New York* (1975), the following soils in the study area have seasonal high ground water less than 2 ft. from the surface: Deerfield sand, Muck, Sudbury sandy loam, Tidal marsh, Wareham loamy sand and Wapole sandy loam. These soils are located primarily within the Beaverdam Creek streambed.

It should be noted that there are no point discharges entering Beaverdam Creek. According to NYSDEC (Philip Barbato pers. comm.), no SPDES permits have been issued at the present time in this area that allow discharge to the creek.

The 100-year tidal floodplain boundary is illustrated on the Watershed Analysis map. The V Zone is that area adjacent to Great South Bay. The **A** Zone is located landward of the V Zone to the inland boundary of the 100-year flood. The **A** Zone includes greater than 50% of the southern section of the study area north to Beaverdam Road. North of Beaverdam Road, the **A** Zone includes the area of the streambed to a width of 300 ft.

The base flood elevation in the study area is 10 ft. above NGVD in the **V** Zone, where structures have to be elevated on piles or piers to these heights or greater; and ranges from 7-9 ft. in the **A** Zone, where the first floor and basement must be elevated over 7, 8 or 9 ft., respectively, above NGVD.

It was estimated that there were 80 residences in the **A** and **V** Zones of the Beaverdam Creek study area as of 1980 (Long Island Regional Planning Board 1984).

The Beaverdam Creek watershed is located in Hydrogeologic Zone **VI**. This zone is characterized by a shallow groundwater system, which directly impacts the water quality in eastern Great South Bay. Because the flushing rate in eastern Great South Bay is so low, contaminant concentrations are not sufficiently dispersed and diluted.

Article 6 of the Suffolk County Sanitary Code, Realty Subdivision and Developments, empowers the Suffolk County Board of Health to control the density of on-site systems in new developments. According to this code, the minimum lot size requirement for a new home with a septic system in Zone **VI** is 40,000 sq. ft. (1 acre).

The ground-water table contour lines, which delineate the water table altitude above NGVD, are shown on the Watershed Analysis map in 5 ft. intervals (Suffolk County Dept. of Health Services 1988). The water table altitude in the Beaverdam Creek study area ranges from the NGVD along the southern portion near Great South Bay, to approximately 20 ft. above NGVD along the northern portion of the study area near Sunrise Highway.

According to Wexler (1988b), ground-water flow in the Upper Glacial aquifer is predominately horizontal and perpendicular to the lines of equal water-table altitude noted above. The general direction of ground water, which originates from the ground-water divide north of the study area, moves in a south to southeastward direction. Ground-water discharges in this study area occur principally as discharge to Beaverdam Creek. The exact point at which flow begins is determined by the point at which the water table first intersects the stream-channel bottom which, for Beaverdam Creek, is between Sunrise Highway and Montauk Highway. Ground water not discharged into the creek moves southward where it eventually discharges to the tidal reaches of the creek or Great South Bay or the Atlantic Ocean.

The Upper Glacial aquifer is recharged by precipitation and to a lesser degree by upward leakage from the deeper Magothy aquifer in this area. The thickness of the Upper Glacial aquifer in the Beaverdam Creek study area is about 100 ft., with a depth to water table ranging from 0 to 45 ft. depending on the land surface elevation. Water in the deeper part of the Upper Glacial aquifer may pass beneath the shallow flow systems associated with Beaverdam Creek as it moves south.

According to Wexler (1988b), groundwater is generally of excellent quality. However, *use of lawn and agricultural fertilizers and discharge from cesspools may have degraded ground water quality in parts of Brookhaven hamlet.*

No public water supply wells exist within the Beaverdam Creek study area. However, approximately half of the existing roadways do have public water mains provided by the Suffolk County Water Authority. According to tests conducted on 88 private wells by the SCDHS, nine exceeded State drinking water standards (Martin Trent pers. comm.). These wells have been identified on the Watershed Analysis map. Contaminated well information for the Beaverdam Creek study area is as follows:

Contaminant	*Standard (ppb)*	*No. of Wells exceeding standard*
trichloroethane	5.0	6
dichloroethane	5.0	4
cis dichloroethylene	5.0	4
vinyl chloride	2.0	3
total coliform	<2.2	1
chloride	250.0	1

The first five contaminants are organic. Excess levels of trichloroethane, the most common organic contaminant, were found in six of the nine contaminated wells. Four wells showed evidence of excess dichloroethane and cis dichloroethylene. Excess vinyl chloride appeared in three wells, and one well exceeded the total coliform standard. Four of these wells have multiple organic contaminations with combinations of trichloroethane, dichloroethane, cis dichloroethylene, and vinyl chloride.

Only one well showed inorganic contamination with excess levels of chloride. It should also be noted that water from the majority of wells in the study area exceeds the State Health Department's standard for iron. This is common for Long Island drinking water. The iron standard is applied for aesthetic reasons, rather than for reasons of public health.

The Suffolk County Dept. of Health Services (James Pim pers. comm.) has inventoried potential toxic waste sites throughout Suffolk County in cooperation with the CLEARS *(Cornell Laboratory for Environmental Applications of Remote Sensing)* program. Two potential toxic waste sites are located immediately outside the Beaverdam Creek study area. One is an abandoned sand mining operation on Beaverdam Rd., just west of the study area. The other is a five-acre area of disturbed land at a highway maintenance site located along the west side of Arthur Ave.

In addition, the Town of Brookhaven operates a lined sanitary landfill for the disposal of municipal solid waste, which is located approximately 2,000 feet northwest of the Beaverdam Creek study area. The landfill was excavated in glacial outwash deposits that form the

Upper Glacial aquifer, and is lined with a 0.02 inch thick polyvinyl chloride (PVC) membrane. Landfilling began in 1974. By 1983, the landfill covered 60 of the site's 180 acres. Today, the landfill covers approximately 65 acres (Elaine McKippen pers. comm.).

According to a report conducted by the Wexler (1988a), water quality in the Magothy aquifer and in Beaverdam Creek did not appear to be contaminated by the landfills' leachate. Further studies are being conducted by USGS at the present time that are re-evaluating the effects of the landfill on nearby ground water and surface waters including Beaverdam Creek.

3.7 Developmental Constraints

3.7.1 Neguntatogue Creek

This section discusses areas in which development should be precluded due to hazardous conditions, or where the adherence to specific performance standards is needed in order to minimize possible impacts. Although there is little land available for development in the Neguntatogue Creek watershed, a review of the Environmental Resources and Watershed Analysis maps reveals several developmental constraints applicable to this study area. Table 3-9 lists the various areas subject to environmental constraints, what the different constraints to development are, and the preferred management measures.

An important constraint to development in this area is the lack of adequate depth to seasonal high water table for proper individual septic system functioning. This occurs in the majority of the area south of Montauk Hwy., as well as along the entire stream corridor. At this time, sewer connections to the SWSD #3 are not mandatory and a number of residences and establishments have continued to use septic systems in these areas which are contributing to possible local water quality impairments.

Another developmental constraint, the 100-year floodplain, encompasses a significant portion of the study area south of Montauk Highway and extends along the stream up to Texas Ave. In addition, the freshwater wetland area, east of Lincoln Ave., presents another developmental constraint in that immediate area.

3.7.2 Beaverdam Creek

A review of the Environmental Resources and Watershed Analysis maps reveals several different constraints to development in the Beaverdam Creek study area. Table 3-9 in section 3.7.1 lists the various areas subject to environmental constraints, what the different constraints to development are, and the preferred management measures.

Multiple constraints to development are found south of Beaverdam Rd. The presence of tidal and freshwater wetlands, lack of adequate depth to seasonal high water table for proper individual septic system functioning, 100-year floodplain, moderate slopes, and beach areas act in concert to discourage additional development in the area between South Country Rd. on the west and Bay Ave. on the east. In addition, this area is a NYSDOS Designated Significant Fish and Wildlife Habitat. It should be noted, that a portion of the large, agricultural parcel along South Country Rd. has fewer constraints to development than the area adjacent to Beaverdam Creek. Future development should be clustered along that portion of the farm near South Country Rd. away from the stream bed and its associated wetlands.

Approximately half of a large old field area on Edgar Ave. falls within the 100-year floodplain and the area with depths to seasonal high water less than 5 ft.

The northern portion of the stream corridor (north of Montauk Hwy.) has several developmental constraints: 100-year floodplain, lack of adequate depth to seasonal high water table, some moderate slopes, and a large, undisturbed area of freshwater wetlands.

In addition, the area west of the stream has a number of moderate slope and swale areas. Appropriate recharge or diversion of stormwater runoff in these areas should be carefully reviewed.

Finally, the entire study area is considered a Critical Environmental Area by Suffolk County under NYS SEQRA regulations. Any future development plans will require the completion of a full environmental assessment form in order for any project to be reviewed for approval/disapproval by local government.

3.8 Watershed Comparison

3.8.1 Existing Land Use

The Neguntatogue Creek study area encompasses 703.2. acres whereas the Beaverdam Creek study area is almost double in size with 1314.0 acres. Both, however, are within the mid- range of the watershed areas that are tributary to Great South Bay. Table 3-10 identifies the parameters discussed in this section for comparing the Neguntatogue Creek and Beaverdam Creek study areas.

Differences in land uses between these two areas are evident. The most significant difference in land use areas is vacant land. Approximately half of the Beaverdam Creek study area is vacant, while in the Neguntatogue Creek study area, only 18.2 acres remain vacant.

In Neguntatogue Creek, the primary land use is high density residential. Together with its secondary land use, medium density residential, these lands account for approximately two-thirds of the total area. Residential land use in the Beaverdam Creek study area is primarily medium density and accounts for approximately 20% of its total area. Low density residential includes approximately 12% of the Beaverdam Creek study area, however, no lands exist within this category in the Neguntatogue Creek study area.

With regard to commercial and industrial uses, the Neguntatogue Creek study area has more than four times the acreage of the Beaverdam Creek study area. In addition, Neguntatogue Creek has a significantly larger number of marine commercial land uses bordering its shoreline. The number of boat slips along Neguntatogue Creek is estimated at 1277, whereas 93 slips are found along Beaverdam Creek.

Transportation uses are similar in the two areas with the LIRR bisecting both stream corridors. The Neguntatogue Creek study area has a train station with related parking facilities adjacent to the creek. Traffic counts for both Montauk Highway and Sunrise Highway in the Neguntatogue Creek study area are almost double those found in Beaverdam Creek .

Furthermore, Neguntatogue Creek has no lands used for agricultural practices; however, the Beaverdam Creek study area has approximately 45 acres of agricultural lands.

Open space accounts for minor acreage in both the Neguntatogue Creek and Beaverdam Creek study areas. Both study areas also have small acreages of institutional uses which primarily include school properties.

3.8.2 Zoning

A comparison of the zoning regulations of the Neguntatogue Creek and Beaverdam Creek study areas shows that both have similar zoning components with, however, different proportions and distributions.

Both areas are zoned primarily for residential use. Lot size requirements in Beaverdam Creek provide for less dense residential areas than those in the Neguntatogue Creek study area. For example, lands bordering on Beaverdam Creek are zoned 2 acre residential,

Table 3-9

Developmental Constraints in the Neguntatogue Creek and Beaverdam Creek Watersheds

Area	*Constraint*	*Preferred Management Options*
Beach	Flooding. Unstable landform subject to erosion and accretion	Preservation.
Major Swales and Depressions*	Area subject to stormwater flooding and groundwater seepage.	Preservation for steep slope swales: maintenance of existing drainage patterns in minor swales.
Depth to Seasonal High Water less than 5'	Interferes with building, laying of pipes and paving.Flooding.Septic system failure.	Preservation for groundwater quality protection:surface water quality protection; wetland protection.
Moderate to Steep Slopes (> 10%)*	Increased runoff, possible flooding, moderate to severe erosion, sedimentation of low lying areas. Roads should be kept to <10 % grade.	Extra grading and stabilization required. Erosion control. Preservation if adjacent to surface water areas.
Flood Hazard Areas - 100-yr. floodplain	Subject to severe flooding during storm periods,septic system failure and possible contamination of fresh water supply.	Preservation.
Freshwater Wetlands and Surface Waters	Subject to flooding. failure of septic systems. protection of vegetation under NYS ECL Article 24.	Preservation.
Tidal Wetlands*	Subject to flooding, failure of septic systems. protection of vegetation under NYS ECL Article 25.	Preservation.
Endangered and Threatened Species of Flora and Fauna*	Species protected under the Federal "Endangered Act of1973," NYS ECL Article 9-1503 (flora) and NYS ECL Article 11-0535 (fauna).	Preservation.

* These areas are not located within the Neguntatogue Creek watershed.

while a significant amount of land along Neguntatogue Creek is zoned 7,500 sq. ft. residential. which is less than a 1/4 acre lot size.

Each study area includes sections that are commercially zoned. Only a small percentage of Beaverdam Creek is zoned general business, most of which is located primarily along Montauk Highway. The Neguntatogue Creek study area. however. has a larger percentage of commercially zoned areas. which are primarily found along Montauk Highway. Hoffman Ave.. Wellwood Ave.. and Sunrise Highway.

Finally. the Neguntatogue Creek study area includes industrially zoned areas along Hoffman Ave. There are no industrially zoned parcels in the Beaverdam Creek study area.

3.8.3 Land Available for Development

A comparison between the Neguntatogue Creek and Beaverdam Creek study areas clearly shows that Beaverdam Creek has more land available for development. The largest land available for development category for both study areas is vacant residential. Additional acreage is available for development in the Beaverdam Creek study area in the following categories: vacant residential old filed subdivision. residential subdividable land. and agriculture. These categories total 276.5 acres with a potential for 640 residential lots. The private recreation and open space category provided few acres for future development in both study areas.

In the Neguntatogue Creek study area there is the potential for 53 additional residential lots. whereas Beaverdam Creek has the potential for 986 lots. Of the 771.3 acres available for development in the Beaverdam Creek study area, only 2.7 acres are available for commercial uses. In Neguntatogue Creek. 4.5 acres of a total of 19.1 acres are available for commercial and/or industrial uses.

3.8.4 Population Analysis

The 1989 population estimate for the Neguntatogue Creek study area is 10,764: it is 1,847 for the Beaverdam Creek study area. The projected saturation population figure for Neguntatogue Creek indicates a 1.5% increase over the 1989 population. In comparison. the Beaverdam Creek saturation population represents a 155.3% increase.

3.8.5 Environmental Resources

As the Environmental Resources maps indicate. a sharp contrast is evident between the Neguntatogue Creek and the Beaverdam Creek study areas. This is primarily due to the extensive development in the Neguntatogue Creek study area. and a significant amount of vacant land found in the Beaverdam Creek watershed.

Both streams are 2.5 miles in length, and have tidal ranges that are nearly identical. The most apparent difference between the two study areas is the amount of tidal wetlands acreage. The Neguntatogue Creek study area contains no tidal wetlands due to extensive shoreline development. In contrast. the Beaverdam Creek study area has a approximately 41 arces of intertidal, high, and formerly connected marsh areas because of the limited amount of development adjacent to the shoreline.

Freshwater wetlands are found in both study areas. However, the Beaverdam Creek watershed contains more abundant freshwater wetlands than the Neguntatogue Creek watershed (121 and 16 acres. respectively). Beaverdam Creek also has three upland habitats that are absent in the Neguntatogue Creek study area (forests. old fields. and agricultural lands).

More species of breeding birds utilize the Beaverdam Creek study area as compared to the Neguntatogue Creek study area (98 to 68, respectively).

Differences in stream usage are evident in both study areas. While Neguntatogue Creek has little fishing activity, Beaverdam Creek is stocked annually with trout and supports recreational and limited commercial fishing. Although waters in both creeks are closed to shellfishing, the NYS Surface Water Classifications indicate that waters in the Neguntatogue Creek have been determined as suitable for fishing and secondary contact recreation. In contrast, the waters of Beaverdam Creek are suitable for fishing, trout spawning, primary and secondary contact recreation.

Beaverdam Creek has been given several special designations including its identification as a Significant Fish and Wildlife Habitat by NYSDOS, a Prime Wildlife Area by NYSDEC and a Critical Environmental Area by Suffolk County under the NYS Environmental Review Act (SEQRA). In addition, Beaverdam Creek is under consideration for inclusion in the New York State Wild, Scenic and Recreational Rivers Act. Such designations have not been assigned to Neguntatogue Creek and environs.

3.8.6 Watershed Analysis

The Neguntatogue Creek study area has an extensive network of interconnected storm drains with a total of 27 discharges to the creek. The Beaverdam Creek study area has a total of 14 storm drains that lead directly into the creek.

Both the Neguntatogue Creek and Beaverdam Creek study areas have generally gradual slopes (0-10%). However, the Beaverdam Creek study area has slopes >10% along a ridgeline west of the creek with swales that convey surface waters toward the streambed.

In both the Neguntatogue Creek and Beaverdam Creek study areas, areas with depth to seasonal high water< 5' are extensive, particularly south of Montauk Highway and Beaverdam Road, respectively.

Point source discharges do not exist in either study area. However, in previous years, three industrial uses were issued SPDES permits in the Neguntatogue Creek study area allowing the discharge of effluents either to surface waters or ground water. In addition, the Neguntatogue Creek study area is presently serviced by the Southwest Sewer District #3. The Beaverdam Creek study area is not sewered: individual septic systems are utilized for sewage waste disposal.

According to 1980 estimates, 452 residences are located within the FIRMs A and V zones in the Neguntatogue Creek study area. For Beaverdam Creek, there are only 80 residences in these zones.

The Beaverdam Creek study area is in Hydrogeologic Zone VI. Minimum lot size for new homes with septic systems in Zone VI is 40,000 sq. ft. The Neguntatogue Creek study area is in Hydrogeologic Zone VII. Both Hydrogeologic Zones are shallow groundwater systems which discharge fresh water to both streams. The range of water table altitude above NGVD in both the Neguntatogue Creek and the Beaverdam Creek study areas is similar. However, the depth to water table is different for both study areas, whereas the range is 0 to 15 ft. in the Neguntatogue Creek study area and 0 to 45 ft. in the Beaverdam Creek study area.

Virtually the entire Neguntatogue Creek study area is serviced by public water provided by SCWA. One public water supply well is located west of the study area which has exceeded State drinking water standards for iron. In the Beaverdam Creek study area, there are no public drinking water supply wells. However, approximately half of the existing roadways in the study area do have public water mains provided by SCWA. Tests conducted on 88 private drinking wells showed that 9 exceeded State drinking water standards. Trichloroethane was the most common organic contaminant found in 6 of the 9 contaminated wells.

An inventory of potential toxic waste sites identified one site just east of the Neguntatogue Creek study area. It is the site of a former landfill, which has now been residentially developed. Potential toxic waste sites identified immediately outside of the Beaverdam Creek study area include an abandoned sand mining operation, 5 acres of disturbed land at a highway maintenance yard site, and a Town of Brookhaven landfill (65 acres) located approximately 2000 ft. north of the study area. Effects of the landfill on nearby ground water and surface waters are being studied at the present time.

3.8.7 Developmental Constraints

Although there is little land available for development in the Neguntatogue Creek study area, there are certain constraints to development that should be noted. In the Beaverdam Creek study area, where over half the land is presently vacant, multiple constraints to development were identified.

Both the Neguntatogue Creek and Beaverdam Creek study areas have a lack of adequate depth to seasonal high water table for proper individual septic system functioning in the areas south of Montauk Highway and Beaverdam Road, respectively, as well as along their stream corridors north of these areas. This problem is of greater concern in the Beaverdam Creek study area due to the fact that sewage treatment plant facilities are not available.

The freshwater wetland east of Lincoln Ave. in the Neguntatogue Creek study area presents a developmental constraint within the immediate area. The extensive freshwater wetlands found north of Montauk Highway and along the river corridor in the Beaverdam Creek watershed also constrain development in these locations.

Both the Neguntatogue and Beaverdam Creek study areas have minimal beach areas. Moderate to steep slopes and associated swales are located in the Beaverdam Creek study area. These features pose certain constraints to development especially with regard to stormwater runoff.

The extensive tidal wetlands in the Beaverdam Creek study area constrain development south of Beaverdam Road along the stream corridor. In addition, the entire study area is considered by Suffolk County as a Critical Environmental Area under NYS SEQRA regulations.

Table 3-10

Comparison of Neguntatogue Creek and Beaverdam Creek Study Areas

Parameter	*Neguntatogue Creek Study Area*	*Beaverdam Creek Study Area*
size of watershed	703.2 acres	1314.0 acres (almost twice as large as Neguntatogue)
primary land use	high density residential- 287.1 acres or 41%	vacant- 681.9 acres or 52%
secondary land use	medium density residential- 175.9 acres or 25%	medium density res.- 295.6 acres or 22%
commercial/industrial uses	113.6 acres or 16%;113 establishments (89 comm./24 ind.).	26.8 acres or <1%; 39 establishments.(36 comm./3 ind.)
marine commercial uses	56.7 acres or 8%;1277 boat slips	6.1 acres; 93 boat slips
primary zoning category	residential (7.500 sq. ft)	residential (.1 acre)
commercial zoning	4 areas along: Montauk Hwy.. Hoffman Ave., Wellwood Ave. and Sunrise Hwy.	1 area along Montauk Hwy.
industrial zoning	mostly along Hoffman Ave.	none
traffic counts	26.398 vehicles/day average Montauk Hwy. 56,473 vehicles/day average Sunrise Hwy. (almost double those found in Beaverdam)	14,826 vehicles/day average Montauk Hwy. 33,028 vehicles/day average Sunrise Hwy.
land available for development	19.1 acres or 3%; 53 potential lots	771.3 acres or 59%; 986 potential lots
land available for development: commercial/industrial	4.5 acres comm./ind.	2.7 acres commercial
1989 estimated population	10,764	1,847
saturation population	10,926	4,716 (43% of Neguntatogue's saturation population)
1989 population density	15.3 people/acre	1.4 people/acre
saturation population density	15.5 people/acre	3.6 people/acre
stream length	2.5 miles	2.5 miles
surface water area	29 acres	25 acres
mean tidal range	0.8 ft.	0.7 ft.
tidal wetlands	0 acces	41 acres
freshwater wetlands	16 acres	121 acres
maritime flora	minimal	extensive on existing dredged spoil areas
Prime Wildlife Area (NYSDEC)	Great South Bay	GSB.Beaverdam Creek and associated wetlands
Significant Fish & Wildlife Habitats (NYSDOS)	Great South Bay	GSB. Beaverdam Creek and associated wetlands
Wild Scenic & Recreational Rivers Act (NYS)	no	yes
Critical Environmental Area (Suffolk County)	no	yes
breeding bird census survey	68 species	98 species
soils	well drained. moderately coarse soils of slight slope	well drained. moderately coarse soils of slight slope
upland habitats	no forests. old fields or agricultural areas of any size	forest: mixed deciduous.pine barrens; old fields; agricultural uses
fishing activity	little	trout stocked annually; supports recreational & some commercial fishing
shellfishing	closed	closed

TABLE 3-10 (cont'd.)

Comparison of Neguntatogue Creek and Beaverdam Creek Study Areas

Parameter	*Neguntatogue Creek Study Area*	*Beaverdam Creek Study Area*
NYS surface water classifications	suitable for fishing and secondary contact recreation	suitable for fishing, trout spawning and primary & secondary contact recreation
slopes	gradual	gradual with >10% swales west of creek
depth to seasonal high water< 5′	500 ft. either side of creek and most of area south of Montauk Hwy.	400 ft. either side of creek with > 50% of area south of Beaverdam Rd.
100 year floodplain	includes a significant portion south of Montauk Hwy. and a portion of the streambed north of Montauk to Texas St.	includes >50% of area south of Beaverdam Rd. and stream corridor north of Beaverdam Rd. to a width of 300′.
point source discharges	none; 3 SPDES permits were issued in previous years	none
sewage treatment plant facility available	yes (SWSD #3); approx. 75% of residences are connected at present time	none
# of residences in FIRMs **A** & V Zones (1980)	452	80
hydrogeologic zone	VII; 20,000 sq. ft. - minimum lot size	VI; 40,000 sq. ft. - minimum lot size
water table altitude above NGVD	0 to 25 ft. above NGVD	0 to 20 ft. above NGVD
depth to water table range	0 to 15 ft. depending on land surface elevation	0 to 45 ft. depending on land surface elevation
thickness of Upper Glacial Aquifer	75 ft.	100 ft.
public water	yes	some areas connected but many have private wells
private drinking well tests by SCDHS	none	88 of which 9 exceeded NYS standards
potential toxic waste sites	1 east of the study area: former landfill	3 immediately outside of the study area: abandoned sand mining operation; highway storage yard; and Brookhaven landfill
developmental constraints	mostly developed: 100 year floodplain; freshwater wetlands; and depth to groundwater < 5′	½ of area is vacant: depth to ground water < 5′; tidal and freshwater wetlands; dredged spoil areas; slopes/swales; and 100 year floodplain

Chapter Four

Stream Environmental Quality

4.0 Introduction

This chapter summarizes field work conducted by the *Marine Sciences Research Center* (MSRC), State University of New York at Stony Brook, to describe and compare the environmental quality of Neguntatogue Creek and Beaverdam Creek. Data on water and environmental quality parameters are portrayed on graphs incorporated into the text of the chapter. Numerical values of the various parameters are tabulated in the appendix to this report.

4.1 Historical Information

More than 30 streams feed into Great South Bay between the Nassau-Suffolk County line and Smith Point. These streams have long been recognized as important conduits of fresh water and fine-grained sediment to the Bay, along with a variety of natural and anthropogenic substances. The watersheds and waterfronts of many of these streams have been extensively developed for residential, general commercial, and light industrial uses, and the streams serve as principal points of access to the Great South Bay for thousands of recreational boaters and a greatly diminished population of baymen.

Notwithstanding the presumptive importance of these streams in influencing water quality in Great South Bay, very little detailed information is available on the quality of their waters or the health and integrity of their biotic communities. This applies to both Neguntatogue and Beaverdam Creeks, particularly the latter.

The headwaters of both streams are located a short distance south of Sunrise Highway. As with all the streams entering Great South Bay, the vast bulk (> 90% in low, baseflow conditions) of the water in both Neguntatogue and Beaverdam Creek is subsurface groundwater that has percolated through the streambed where it is below the water table (Suffolk County Executive Office: Special Projects 1980). Overland runoff of precipitaton is a minor contributor to total streamflow during dry, baseflow conditions. Reliable, quantitative data on the apportionment of total streamflow between upwelled groundwater and overland runoff during and immediately after rainfall events were not available for either creek. However, streamflow data from the U.S. Geological Survey from streams in the vicinity of Neguntatogue and Beaverdam Creeks (neither of which is gauged) suggest that rainfall events can produce, for periods of a few days, mean daily discharges 4-5 times higher than long-term mean daily discharges and instantaneous maximum flows an order-of-magnitude or more higher than long-term mean daily discharges.

4.1.1 Neguntatogue Creek

The bulk of the existing information on the physical, chemical, geological, and biological environment of Neguntatogue Creek derives from the study of this stream as part of Suffolk County's *Flow Augmentation Needs Study* (FANS) (Suffolk County Executive Office: Special Projects 1980). The FANS Study was undertaken to assess the probable extent of decreased streamflow and other impacts attendant to the sewering of Nassau County Sewer District No. 3 and Suffolk County Sewer District No. 3. Sampling in Neguntatogue Creek under the FANS Study was done in 1978. The sewer system became operational in the drainage area of the creek in the fall of 1981. The FANS study focused solely on the freshwater portion of the Creek. No historical information on water quality or biotic characteristics of the marine portion of Neguntatogue Creek was identified during the present study.

Components of the FANS study included:

- analysis of streambed geology (horizontal & vertical)
- streamflow determination
- floral & faunal analysis, including terrestrial and aquatic environments
- water quality analysis

Neguntatogue Creek was rated the lowest in overall water quality of the 22 streams examined during the FANS study, based on its average ranking across a number of physical and chemical parameters. A survey under the FANS Study of freshwater fauna and flora in the Creek found a complete absence of fish and aquatic macrophytes and a benthic community comprised of only two families of aquatic worms and one family of midge. The watershed of Neguntatogue Creek has been extensively developed since the 1940s. Land use in the watershed of the Creek is primarily high density residential, but includes a variety of commercial and light industrial facilities, including extensive marina development in the marine segment of the stream. The freshwater segment has been extensively culverted and channelized in large stretches, while the marine portion has been almost completely bulkheaded. Prior to the installation of sanitary sewers, Neguntatogue Creek was subject to extensive infiltration of leachate from residential septic systems and, apparently, some direct industrial discharges, particularly from a dairy processing facility located in the mid-stream area. Available data from the NY *State Pollutant Discharge Elimination System* (SPDES) indicates that Neguntatogue Creek does not currently receive any direct industrial discharges. As of this writing, approximately 75% of the residences in the watershed of Neguntatogue Creek, and 64% of the commercial and industrial establishments, are hooked up to the sewer system. The Creek continues to be impacted by stormwater runoff from the surrounding streets, parking lots, and other paved surfaces.

4.1.2 Beaverdam Creek

Historical information on the water quality and environmental health of Beaverdam Creek is exceedingly sparse. From 1970-1972, periodic surveys of the stream were conducted by the Fresh Water Resources Bureau of the Suffolk County Department of Health. Standard physiochemical constituents and parameters were measured (nitrogenous nutrients, pH, coliform bacteria, chloride, total solids, etc.). Samples were apparently taken from a single station in the freshwater segment of the creek. A 1973 unpublished report by a student at Alfred University (Brown 1973) summarizes the earlier County Health Department data and presents limited new data on inorganic nutrients and chlorophyll a values in Beaverdam Creek waters.

Land use in the watershed of Beaverdam Creek is a mixture of vacant and agricultural land with low-to-medium density residential development. The marine segment has been dredged and the area around the mouth of the Creek is substantially altered, with several artificial canals dug in association with a housing development. Two small marinas/boatyards are located in the marine portion of the Creek. Much of the original fringing *Spartina* marsh is gone, but enough of the native vegetation remains along the marine and freshwater segments to give Beaverdam Creek a very *natural* look. As a *semi-rural* stream, it makes an effective counterpoint to Neguntatogue Creek.

4.2 The Field Sampling Program

A wide variety of biological, physical, chemical, and geological factors combine to create a particular environment. Time and resources did not permit an analysis of all such factors in Neguntatogue Creek and Beaverdam Creek. The field sampling program examined a limited number of physical and chemical parameters that have traditonally been used to describe the quality of freshwater and marine environments, along with descriptions of the quantity and quality of several biotic assemblages in the streams. This approach will, we believe, be adequate to describe and compare the two streams for the purpose of examining the impact of land use on their respective quality.

4.2.1 Physiochemical Parameters

WATER TEMPERATURE - Most of the biological, chemical, and geochemical processes that define the relationship of an organism to its aquatic or marine environment are temperature-dependent. Field data were collected during the warm months (April-August), when the effects of temperature are probably at a maximum.

DISSOLVED OXYGEN - Chronic low levels of dissolved oxygen can severely reduce the habitability of a waterbody to most organisms. Temporary, but acute depressions in dissolved oxygen levels can likewise have significant negative effects on biota. The severity as well as the spatial and temporal extent of hypoxic conditions in the two streams reflects the interaction of oxygen-producing and oxygen-consuming processes. Anthropogenic impacts including excess loadings of nutrients and/or organic material can shift the balance of these two processes towards oxygen consumption, particularly in bottom waters.

STREAMFLOW - In addition to being an important determinant of instream habitat quality in the freshwater reaches of the streams, streamflow is a rough measure of the capacity of the streams to transport materials from their freshwater to their marine reaches, from whence some of these materials may be transported to the open waters of the Great South Bay. Streamflow is also an important aesthetic attribute of such streams.

SALINITY - Most estuarine organisms have fairly broad salinity tolerances (euryhaline), necessary in an environment where substantial salinity changes occur over short spatial and temporal scales. The response of salinity in the marine reaches of the two creeks to rainfal events is of particular interest.

INROGANIC MACRO-NUTRIENTS - Enrichment of fresh and marine waters with excess nutrients can produce advanced eutrophic conditions, including nuisance blooms of phytoplankton and macrophytes which can lead to the establishment of hypoxic conditions as this increased biomass is microbially decomposed in bottom waters. Also, the relative amounts of the various nutrients present in the water column influence the species composition of phytoplankton in fresh and marine waters. Nutrients leaching into Neguntatogue Creek from septic systems in the surrounding watershed were identified by the FANS Study (Suffolk County Executive Office: Special Projects 1980) as a primary water quality problem prior to installation of sewers in the region.

SEDIMENT ANALYSES - The sediments of a waterbody are closely coupled to the overlying waters. In particular, excessive organic debris and various industrial pollutants (metals, PCBs, pesticides) have a propensity, when introduced into aquatic and marine environments, to adsorb onto fine-fraction suspended sediments. These materials of concern are then transported through the environment with the suspended sediment load, eventually settling to the bottom in areas where current velocities are low. Once in the sediments, these pollutants are subject to periodic resuspension, transport, and/or various mechanisms of biological action and mobilization until they are eventually broken down into more refractive materials or become permanently incorporated into the sedimentary environment. The relative abundance of heavy metals and organic material in aquatic or marine sediments is a more stable characteristic of these environments and serves to integrate the more variable presence of these materials in the water column. Both streams, especially Neguntatogue Creek, receive heavy metals through street runoff, marina and boat operations, and atmospheric deposition. No active SPDES permits, governing direct discharge of industrial effluent, are on file for either creek.

Sediment parameters examined in the present study were grain size, loss on ignition (organic content), and the concentrations of selected heavy metals.

4.2.2 Biologic Parameters

COLIFOM BACTERIAL LEVELS - Total and fecal coliform bacteria in fresh and marine waters are used as surrogates for pathogenic bacteria and viruses associated with human sewage in determining the relative risk posed by these waters to various human uses, including bathing and shellfishing. Coliform bacteria occur naturally in the environment as well, in soil and in the guts of all warm-blooded animals. Both streams support fairly abundant waterfowl populations. Because of elevated coliform levels in open Bay waters immediately outside their mouths, both Neguntatogue Creek and Beaverdam Creek are closed to shellfishing. We were interested in examining the levels of coliform bacteria in the creeks proper and to identify the source(s) of this contamination to each stream.

PHYTOPLANKTON ABUNDANCE/PRODUCTIVITY/SPECIES COMPOSITION - Phytoplankton account for about 85% of the total primary production in the Great South Bay (Lively et al. 1983). Disruption in the phytoplankton can augur significant changes in the abundance and distribution of higher trophic level organisms. Phytoplankton assemblages are influenced by many environmental factors, including the total concentration of nutrients in the water column as well as the relative amounts of individual nutrients. The nature, extent, and productivity of phytoplankton assemblages can also be influenced by the presence of various organic toxicants. For example, nutrient enrichment may favor the dominance of smaller phytoplankton, while it appears that larger species are somewhat more resistant to the effects of organic pollutants. Phytoplankton production (chlorophyll a), total abundance, and species composition were assessed in the freshwater and marine reaches of each stream.

BENTHIC MACROFAUNA - Benthic invertebrates are an important component of the food web of freshwater and, particularly, marine systems. The benthos provides a food source for many commercially and recreationally important finfish and are also a means by which various pollutants in aquatic or marine sediments may be remobilized and made available to higher level consuming organisms. There is a vast literature documenting the differential impact of various substances, natural and anthropogenic, on benthic invertebrates. Because of their limited mobility, the nature, abundance, and health of benthic macrofaunal populations can be used to evaluate the level of environmental stress in an area. In some cases this stress is inherent in the system; in some cases it may reflect various anthropogenic impacts to the system. Benthic studies assessed the abundance, distribution, species composition, species diversity, and species richness of macrobenthic communities in the streams.

AMBIENT WATER BIOASSAYS - Bioassays are gaining increasing use as a means of integrating a variety of physiochemical factors into a single diagnostic test to measure the quality of fresh and marine waters. In this study ambient water bioassays were employed, using full strength water from each creek along with a series of dilutions. These tests were not intended to identify specific compound(s) responsible for whatever mortalities were observed. Their use was to evaluate any acute toxicity in the fresh and marine waters of either creek to biota, or to suggest the presence of chronic levels of toxicity.

Eight stations were established in each stream, running from a location at or very near the source of the stream down the stream's length to a final station at the mouth. The exact location of the stations represented a balance between:

- an attempt to achieve even longitudinal coverage of the stream
- accessibility (an important factor in the freshwater reaches)
- the location of probable pollutant sources or adverse hydrographic conditions

Two additional stations were located in open Bay waters south of the mouth of each stream (stations N9 and B9). Station locations in Neguntatogue Creek are shown in Figure 4-1; stations in Beaverdam Creek are shown in Figure 4-2.

Stations were sampled monthly from April to August, 1989. Several of the parameters to be measured were likely to vary over short time scales (hours to days); it was imperative that the sampling be as synoptic as possible. This was particularly important in view of the overriding interest in comparing the quality of the two streams. Both streams have freshwater reaches that are accessible only from the bank and marine reaches that can be effectively sampled only from a boat. The two streams are approximately 25 miles apart. The logistical problem of sampling the two streams synoptically was solved by having two field teams operating independently, one sampling the freshwater reaches of both streams while the other team sampled the marine reaches. Beaverdam Creek was usually sampled first, followed by Neguntatogue Creek. This system was employed beginning with the May sampling. The April sampling was not synoptic, Beaverdam Creek samples being taken on 07 April and Neguntatogue Creek samples on 10 April. However, the intervening period was dry with little apparent change in meteorological conditions.

Given the limited duration of the study, it was not possible to sample these streams so as to fully document and evaluate seasonal variability in water quality. However, by focusing on the warm weather months, information on worst-case conditions was obtained. Attempts were made to sample at least once in both drought, low-flow conditions and immediately following heavy rainfall. However, the summer of 1989 was wet, without the periods of extended hot, dry weather that have characterized several recent summers in the northeast U.S.

Table 4-1 details the sampling scheme employed in this project, identifying the parameters measured, and the stations/sampling dates at which each parameter was measured.

4.3 Analytical Methods

4.3.1 Physio-chemical Parameters

At each station, water temperature, dissolved oxygen, and pH were measured *in situ* using a MARTEK Mark VI Water Quality Analysis Unit, a portable unit with 4 digit readout that operates on external batteries (8 "D" cell pack or 12 VDC) or 120 Volt AC. Two units were used, one from the small boat at marine stations and another configured as a backpack setup for sampling the shallow freshwater stations. At marine stations, the unit also read conductivity, which was subsequently converted to salinity through a calibration algorithm.

At all freshwater stations, total (methyl-orange) alkalinity as calcium carbonate ($CaCO_3$) was determined on station using a Hach titration alkalinity test kit (Model AL-AP).

Streamflow measurements were made using an Otto Kempen handheld, direct readout, propellor-driven current meter. At stations where variable bottom topography induced obvious variability in flow across the stream's width, several readings were taken across the stream and averaged.

Physio-chemical variables were measured in surface (0.5 m) and bottom waters of all marine stations, except during the April sampling, when only surface data were taken, except for dissolved oxygen. The freshwater sections of these streams are very shallow (usually < 2 feet) and only a single, midwater reading was taken.

NUTRIENTS - Surface water samples for macronutrient analysis were taken in April, June, and August at one freshwater and one marine station in each stream (N3, N6 and B3, B6) as well as at the two open bay stations (N9, B9). Macronutrients analyzed were nitrate, nitrite, ammonium, and orthophosphate. Sample bottles were stored in iced coolers until returned to the laboratory. Samples were filtered in duplicate through a 0.2µm Millepore filter to remove all particles and then measured using an Auto Analyzer II system as described in D'Elia et al. (1987).

CHLOROPHYLL a - Surface water samples for chlorophyll a analysis were taken at all stations on all sampling dates. Sample bottles were stored in iced coolers until returned to the laboratory. Phytoplankton were filtered on GF/F filters in triplicate for each station and extracted in 90% acetone for 24 hours. Chlorophyll a was then determined by a fluormetric measurment as described by Yentsch and Menzel (1963).

PHYTOPLANKTON COMPOSITION - Surface water samples for analysis of phytoplankton abundance and species composition were taken in April, June, and August at a freshwater and a marine station in each stream (N3, N6 and B3, B6) and at the two open bay stations (N9, B9). Samples were stored on ice in coolers until returned to the laboratory, where they were fixed in Lugols solution and stored in cold and dark conditions until counted.

SEDIMENT ANALYSES - Stream sediments were analyzed for grain size, organic content (loss on ignition), and concentrations of the metals copper, lead, zinc, and manganese. Sediment samples were taken in May. Sampling at the marine stations was done with a 0.1 m^2 Ponar grab; at freshwater stations, samples were taken with a 0.03 m^2 hand-held grab. From the grab samples, two subsamples were taken on station, one for metal analysis and the other for grain size/loss on ignition. Samples were kept in iced coolers until returned to the laboratory.

Samples for grain size and loss on ignition analysis were homogenized in the sample jar and a separate subsample for each then taken. Particle size distribution was determined by wet sieving and pipette analysis (Folk 1964). Grain size samples were dispersed with a 1% Calgon solution and wet-sieved through 2mm and 63µm mesh sieves to separate the gravel, sand, and mud fractions. The

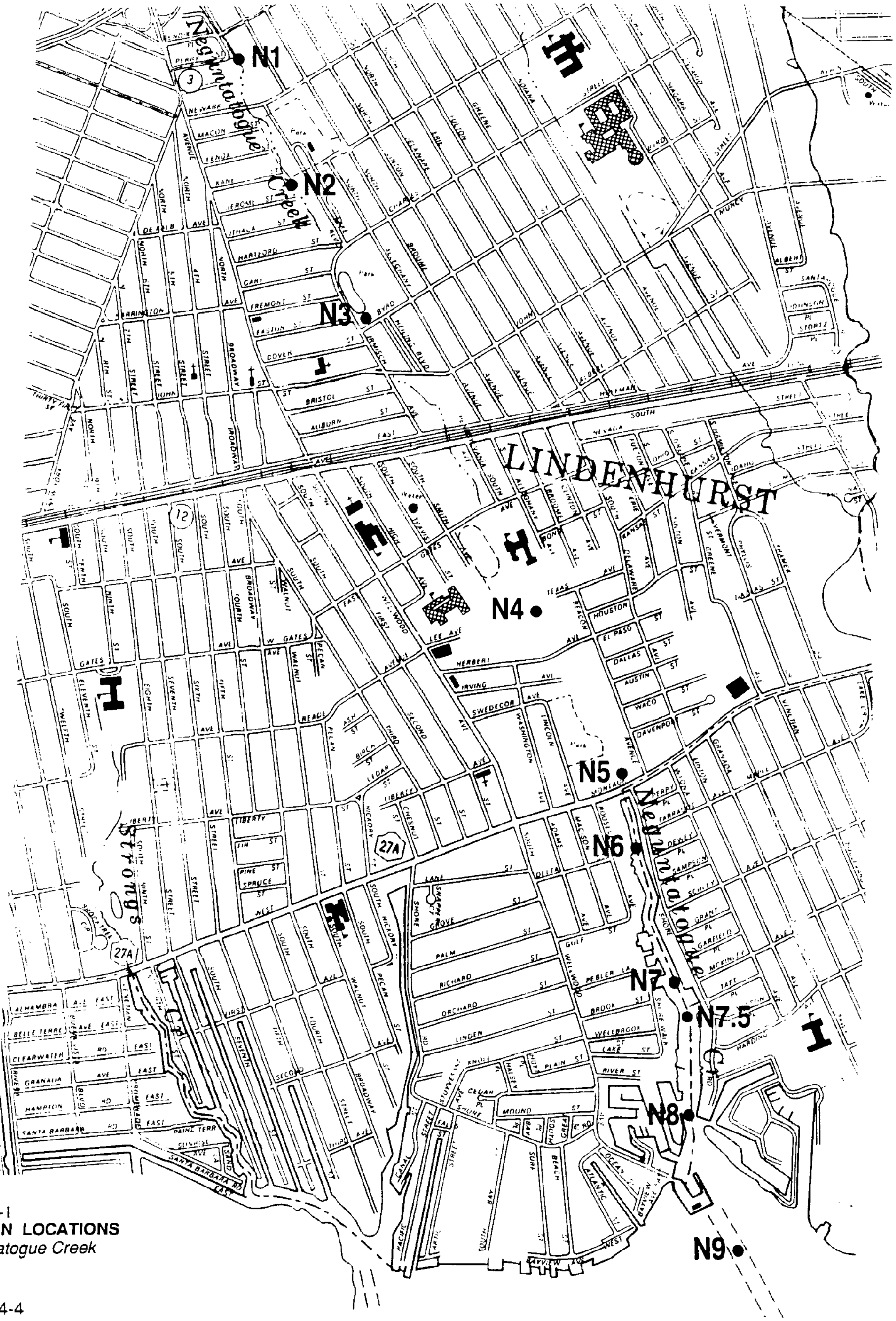


Figure 4-1
STATION LOCATIONS
Neguntatogue Creek

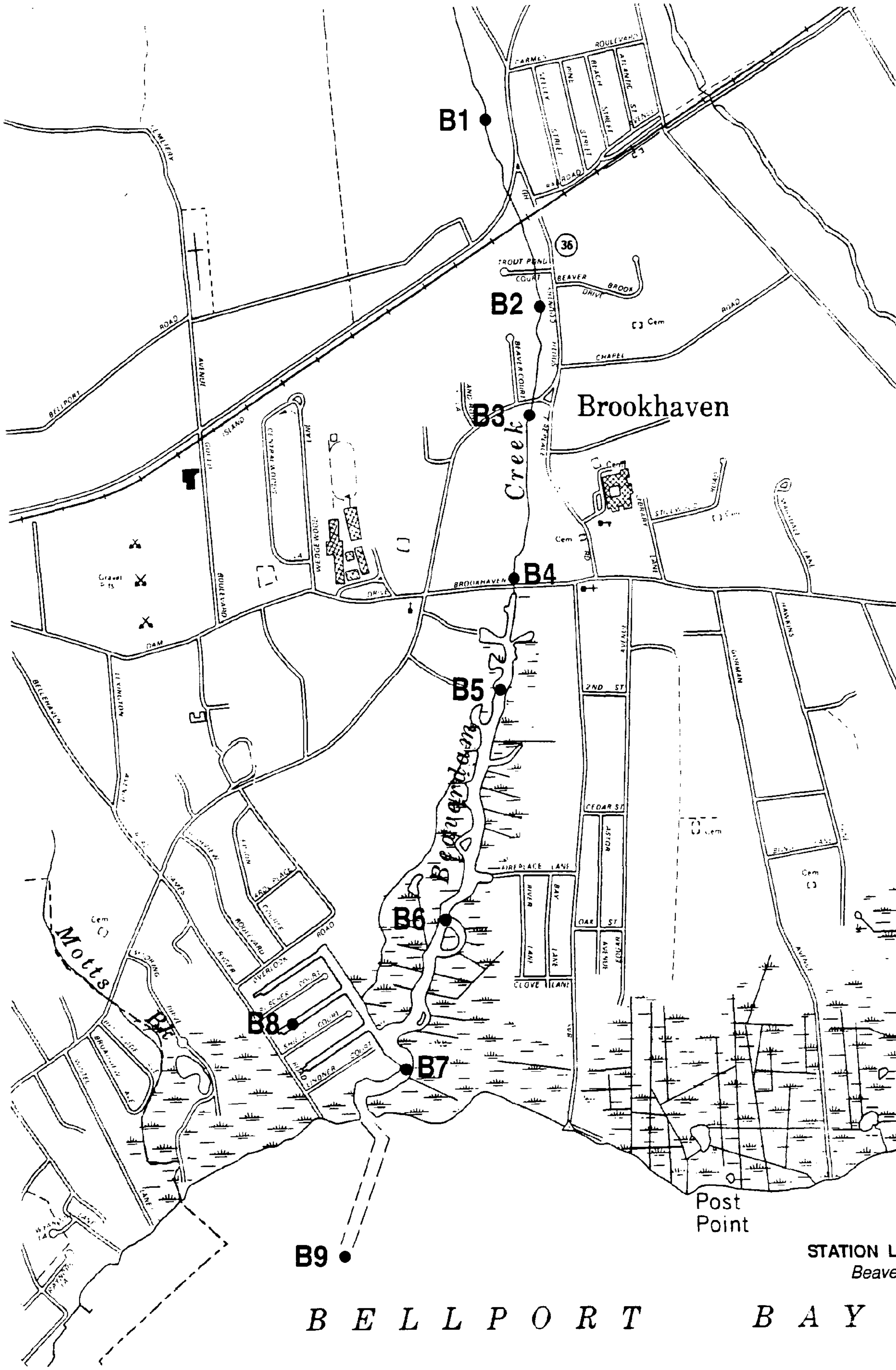


Figure 4-2
STATION LOCATIONS
Beaverdam Creek

TABLE 4-1

Sampling Schedule

Sample	*Station*	*April*	*May*	*June*	*July*	*August*
Temperature	All	X	X	X	X	X
Dissolved Oxygen	All	X	X	X	X	X
Streamflow	N2,N4,N5,B2,B3,B4	X		X	X	
Salinity	N6,N7,N7.5,N8,N9, B5,B6,B7,B8,B9	X	X	X	X	X
Alkalinity	N1,N2,N3,N4,N5 B1,B2,B3,B4	X	X	X	X	X
pH	All	X	X	X	X	X
Nutrients	N3,N6,N9,B3,B6,B9	X		X		X
Chlorophyll a	All	X	X	X	X	X
Phytoplankton	(See Nutrients)	X		X		X
Sediment	All		X			
Coliform bacteria	N4,N7,B4,B7		X	X	X	
Benthos	All		X		X	X
Bioassay	N4,N6	X		X		X

mud fraction was then separated into silt and clay through pipette withdrawals. The several fractions were then dried in an oven for 24 hours at 90 °C, cooled to room temperature, and weighed.

Samples for percent (by mass) loss on ignition analysis were dried in an oven, disaggregated, and dry-sieved through a 2mm sieve to remove the gravel fraction. Approximately 20 grams of sample material were combusted at 550°C for 5 hours, cooled, and weighed to determine percent mass loss on ignition.

Analysis of hydrofluoric/boric acid digests by atomic adsorption spectrophotometry was used to determine the concentrations of cooper, zinc, lead, and manganese in stream sediments, using a method modified from that of Silberman and Fisher (1979). Sediment samples for metal analysis were freeze-dried and ground using a mortar and pestle. Approximately 0.5 g of dried sample was then weighed to 0.1 g and placed into 125 ml Nalgene plastic bottles with 10 ml of distilled-deionized water and 10 ml of concentrated hydrofluoric acid (HF). The mixtures were shaken for 24 hours, whereupon 70 ml of saturated boric acid solution was added and the sample shaken again for 24 hours, followed by ultrasonication for one hour. Digests were filtered through a 0.45 µm Millepore filter and transferred to 100 ml glass volumetric flasks and brought to volume with saturated boric acid. Digests were refrigerated at 5°C prior to analysis. Three replicate samples from each station were analyzed for Cu, Pb, Mg, and Zn by atomic adsorption spectrophotometer (AAS), using a flame graphite furnace.

In an effort to better understand the sources, distribution, and fate of metals in the streams, water samples at all freshwater stations were taken in August for the determination of water column dissolved metal concentrations (Zn, Pb, Cu, and Mn). Water samples were taken in 300ml plastic bottles and kept on ice until returned to the laboratory. In the laboratory, the sample was shaken and 100ml transferred to a 250ml glass beaker, to which was added 2.0 ml (1+1) HNO_3 and 10.0 ml (1+1) HCL. The beaker was covered with a watch glass and heated on a hotplate for 2 hours at 95°C until the volume was reduced to 25-50ml. The sample was then cooled and filtered to remove any insoluble material. The sample volume was adjusted to 100ml with deionized distilled water and then analyzed by furnace atomic absorption spectrophotometer.

4.3.2 Biologic Parameters

COLIFORM BACTERIA - In May, June, and July, surface water samples for coliform bacteria analysis were taken at one freshwater and one marine station in each stream (N4, N7 and B4, B7). Samples were taken in clean, screw-capped 38 mm x 200 mm culture tubes. Following procedures of the Shellish Sanitation Laboratory of the New York State Department of Environmental Conservation (DEC), three tubes were taken at each station, one experimental tube, one temperature control, and one field blank. Samples were stored on ice and brought to the DEC shellfish sanitation laboratory on the SUNY/Stony Brook campus immediately upon return from the field. Bacterial analysis was conducted by DEC staff following procedures set out by the American Public Health Association (1970).

BENTHIC MACROFAUNA - Samples of benthic macrofauna were collected at all stations in May, July, and September. Samples at marine stations were collected with a 0.06 m^2 Ponar grab. Freshwater samples were taken with a hand-held 0.03 m^2 grab. Samples were wet-sieved on station through a 1 mm Nitex screen. After washing, all remains on the screen were preserved in 10% buffered formalin with rose bengal stain. In the laboratory, benthic samples were rewashed using a 1 mm screen. Animals were picked out from the samples under a dissecting microscope and transferred to 70% ethyl alcohol for subsequent identification and enumeration. Sorted animals were identified to the species level, if possible. Total numbers were determined for each species or for a higher taxonomic group when identification to species level was not possible.

Abundance, species richness, and a species diversity index were calculated. Abundance is the number of animals per m^2, obtained by multiplying organism counts by a conversion factor. Conversion factors were determined based on the sampling unit area (freshwater sample 0.03 m^2: marine sample (0.06 m^2). Species richness is presented as the number of species per unit sampling area. The species diversity index was calculated using the following Shannon-Wiener function:

$$Isd = \sum_{i=1}^{n} Pi \log_{10} Pi$$

where i is the total number of species and Pi is the proportion of individuals in the sample of the ith species.

AMBIENT WATER BIOASSAY - Bioassay tests were conducted using ambient stream water from stations N4, N6, B3, and B6 collected during the April, June, and August samplings. Surface water from each station was stored in 5-gallon carboys and returned to Cosper Environmental Labs, Inc. of Northport, NY, where the carboys were kept cool and dark until the tests were initiated. Bioassay tests were initiated within 24 hours of sample retrieval. The tests were 96-hour acute daily replacements. Freshwater samples were tested using the fathead minnow, *Pimephales promelas*, and the cladoceran, *Ceriodaphnia dubia*. Marine samples used the sheepshead minnow, *Cyprinodon variegatus*, and the mysid shrimp, *Mysidopsis bahia*. Control water for the marine tests was from central Long Island Sound; control water for the freshwater tests was reconstituted well water. For each sample, the following dilutions of sample water were assayed: 100%; 50%; 25%; 12.5%; and 6.25%. Results are reported as percent mortality of test organisms.

4.4 Results of the Field Sampling Program

4.4.1 Salinity

In their marine reaches, streams such as Neguntatogue and Beaverdam Creeks are transformed into mini-estuaries, frequently displaying sharp vertical and horizontal gradients in salinity. Salinity at the surface and bottom was recorded for all stations during each sampling event, except in April, when only surface salinities were taken. Salinity data are shown in Figures 4-3 and 4-4.

Salinities in both surface and bottom waters of Neguntatogue Creek were, on average, several parts per thousand higher than in Beaverdam Creek. This is attributable to Neguntatogue Creek's proximity to Fire Island Inlet, a major source of higher salinity ocean water to the Great South Bay. The vertical gradients in salinity were less pronounced in Neguntatogue than in Beaverdam Creek, particularly in the more southerly marine stations: the data suggest that a traditional estuarine two-layer density structure and circulation is a more persistent feature of Beaverdam Creek than of Neguntatogue Creek. In both streams, this vertical salinity structure was more pronounced in the spring and lessened as the season progressed.

4.4.2 Temperature

Ambient water temperature is a critical environmental parameter because it affects the metabolic rate of biota and the rate of a variety of physiochemcial reactions in the aquatic environment. It directly affects dissolved oxygen tensions in the water column.

Surface and bottom temperatures were taken at all marine stations during all sampling events except April, when only surface water temperatures were obtained. Only one measurement was made at freshwater stations. Temperature data are shown in Figures 4-5 to 4-7 .

Water temperatures in the marine reaches of both streams are 2-4°C higher than in the freshwater reaches; this reflects the dominance of cooler groundwater as the primary source of water to the freshwater portions of these streams. Bottom water temperatures are higher than surface temperatures at the more landward marine stations in both streams, a result of the inflow and superposition of cooler water from upstream over the more saline, warmer marine waters. As one progresses towards the mouth of both creeks, this vertical temperature difference diminishes and, at the open bay stations south of the creek mouths, the water column is basically of uniform temperature. Both streams displayed the expected seasonal variation in water temperatures, with a summer maximum in July and August. On balance, there is little difference in the temperature regimes of the two streams.

The FANS Study (Suffolk County Executive Office: Special Projects 1980) documented a temperature range in the freshwater reaches of Neguntatogue Creek in July, 1978 of 16-23°C across 8 stations, agreeing well with data from the present study, which show a temperature range in July, 1989 of 14.5-24.7°C at Neguntatogue Creek freshwater stations.

4.4.3 Dissolved Oxygen

Dissolved oxygen is an important determinant of the habitability of a waterbody for marine organisms. When dissolved oxygen levels fall below 3.0 mg/L (hypoxic conditions), most marine organisms begin to experience stress and, unless oxygen concentrations increase or the organism moves, persistence of depressed oxygen levels can cause the animals to suffocate. A dissolved oxygen concentration of approximately 4.0 mg/L is viewed as the minimum long-term average required to avoid significant hypoxic impacts to marine fauna.

Sources of dissolved oxygen in natural waters include photosynthesis and atmospheric inputs; sinks include respiration, vaporization, and various chemical reactions. As noted above, water temperature can play a significant role in determining the oxygen carrying capacity of a body of water, both directly and through mediation of various oxygen-producing or oxygen-consuming biological and chemical reactions.

Surface and bottom water dissolved oxygen data were recorded at each marine station during all sampling events, except in April, when only surface readings were made. Only one measurement was made at freshwater stations. Dissolved oxygen data are shown in Figures 4-8 to 4-10.

Due to the shallow water depths and continual flow, dissolved oxygen levels in the freshwater stretches of both streams stayed above critical levels (approximately 4.0 mg/L) except at the two most northerly freshwater stations in Neguntatogue Creek (N1 & N2). Oxygen levels in the freshwater portion of Beaverdam Creek remained above 4.0 mg/L throughout the study period. There was a general decline in dissolved oxygen at all freshwater stations from April to August.

At the marine stations in Neguntatogue Creek, surface dissolved oxygen concentrations were generally high except at the two northernmost stations during the July sampling. The marine surface waters of Beaverdam Creek were generally well-oxygenated, except at station B5 beginning in May, when persistent hypoxic conditions set in and remained throughout the balance of the duration of the study. The super-saturated levels of dissolved oxygen detected in the surface waters of stations B6, B7, and B8 reflect accelerated photosynthesis at these sites stemming from phytoplankton blooms. Beginning in May, the bottom waters of Beaverdam Creek were usually mildly to severely hypoxic with the exception of station B6 in August. Particularly low values were recorded at station B8, the back end of one of several canals created in association with a residential development. The bottom waters of the northern portion of Neguntatogue Creek's marine reach were severely hypoxic for most of the sampling period.

4.4.4 Alkalinity

The alkalinity of a waterbody is a measure of its capacity to neutralize acids. The alkalinity of natural waters is due primarily to the salts of weak acids, although strong or weak bases may also contribute. Bicarbonates represent the major form of alkalinity, since they are

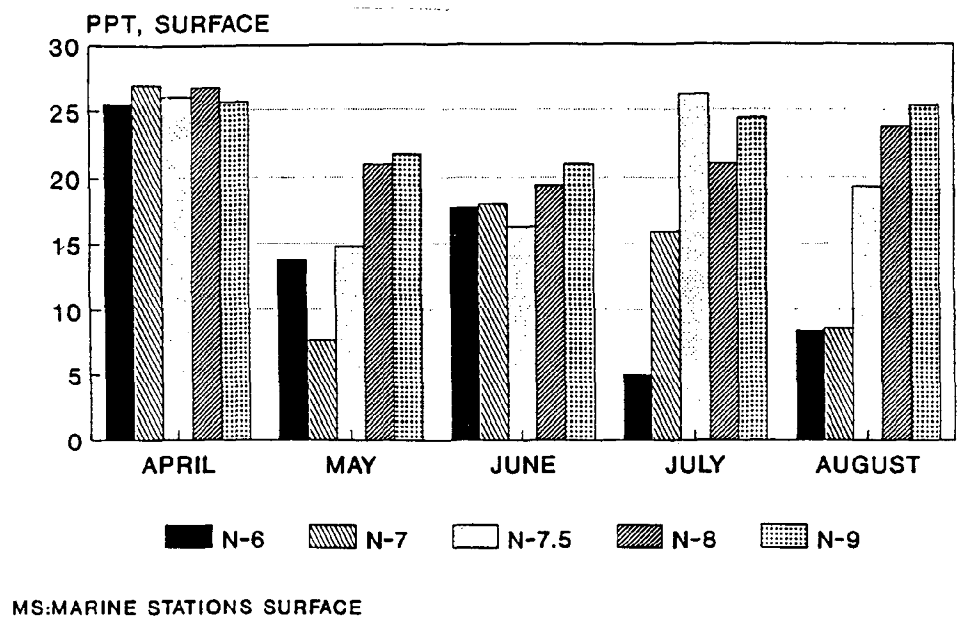


Figure 4-3(a)
SALINITY
Neguntatogue Creek (MS)

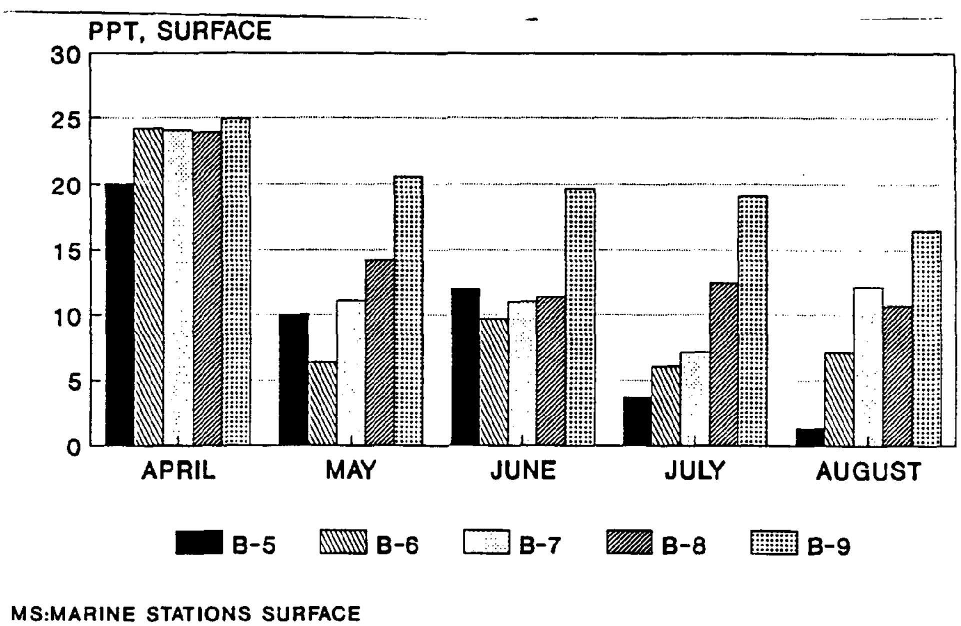


Figure 4-3(b)
SALINITY
Beaverdam Creek (MS)

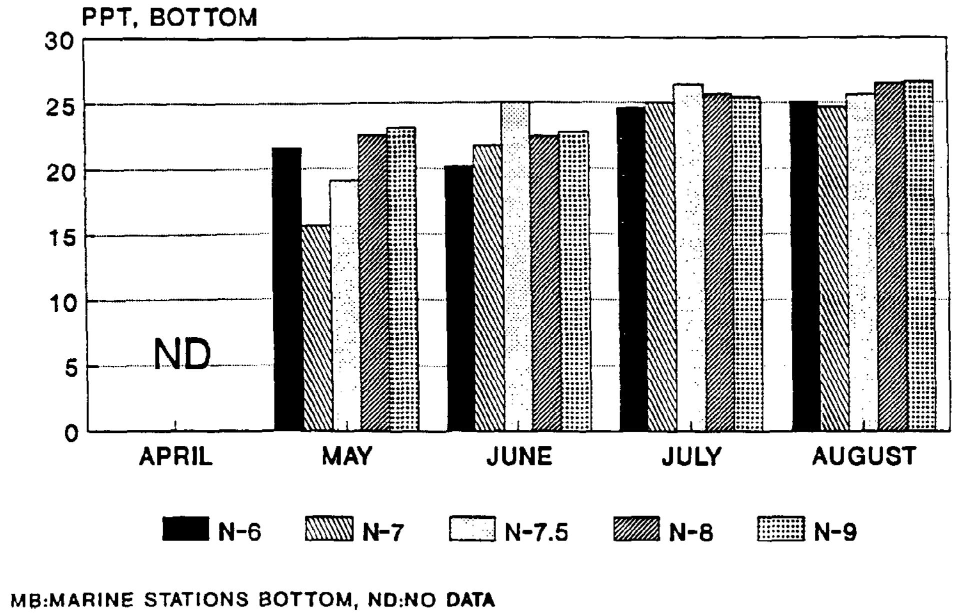


Figure 4-4(a)
SALINITY
Neguntatogue Creek (MB)

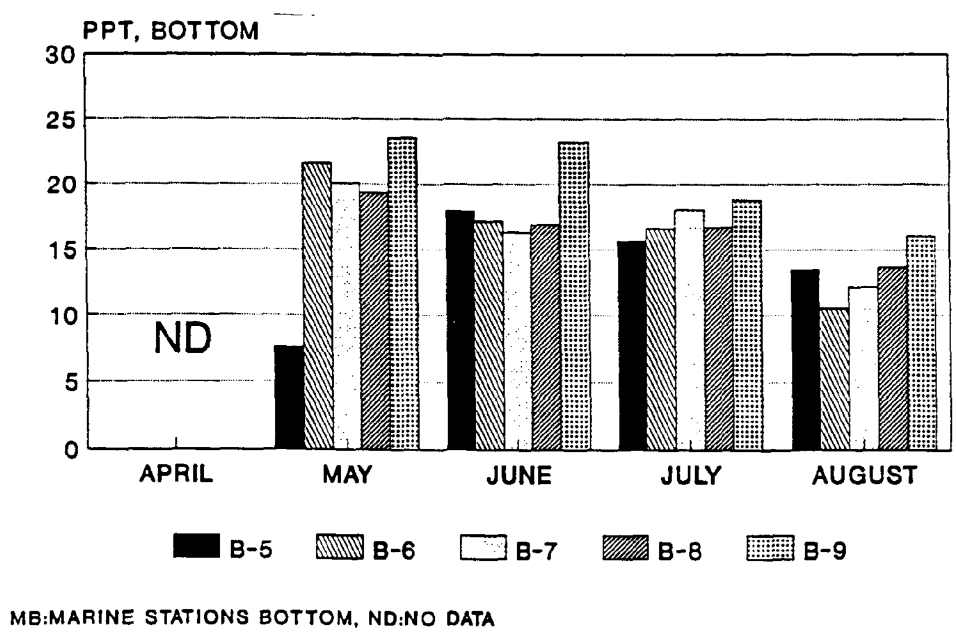


Figure 4-4(b)
SALINITY
Beaverdam Creek (MB)

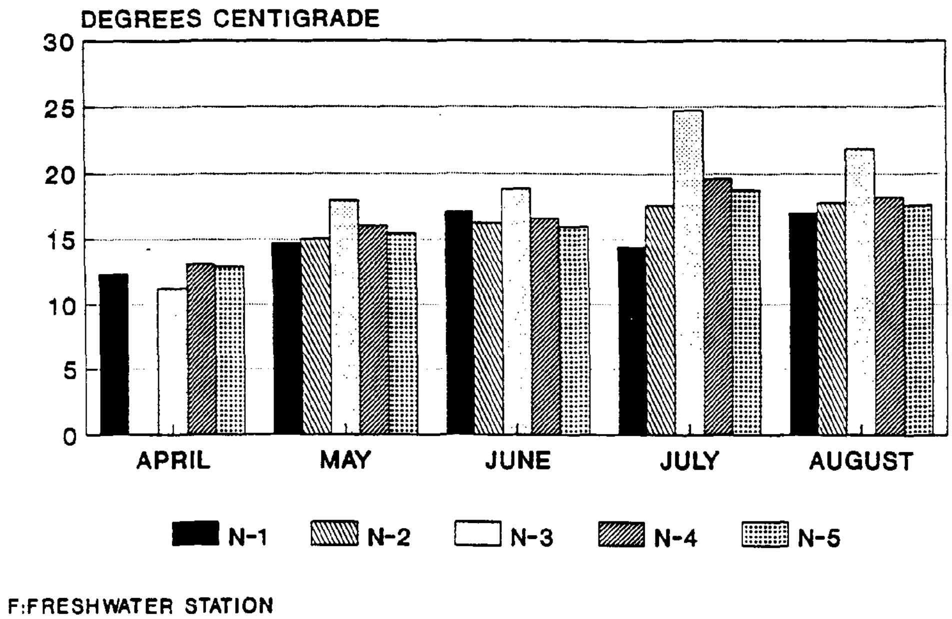


Figure 4-5(a)
TEMPERATURE
Neguntatogue Creek (F)

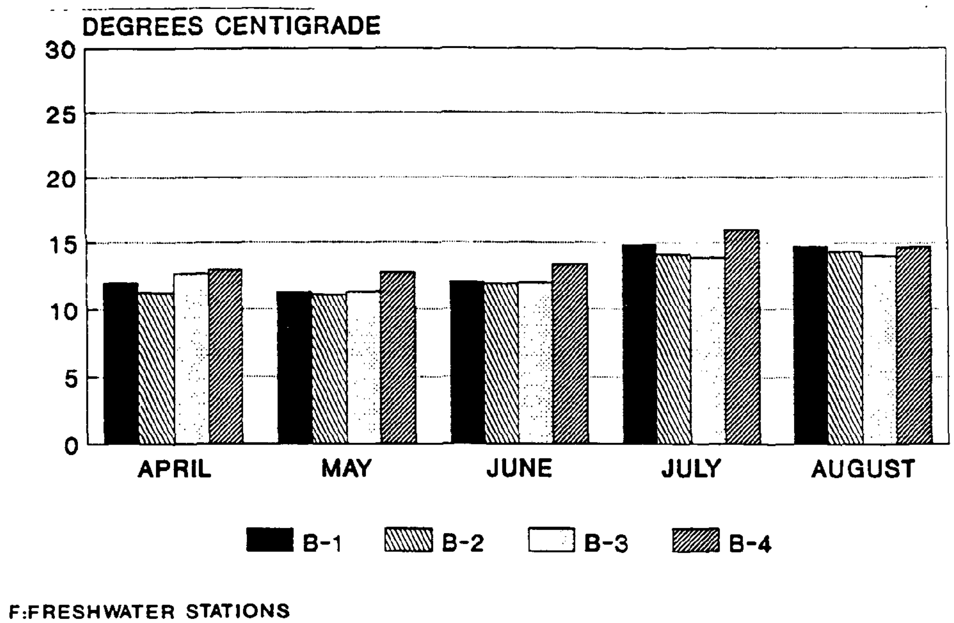


Figure 4-5(b)
TEMPERATURE
Beaverdam Creek (F)

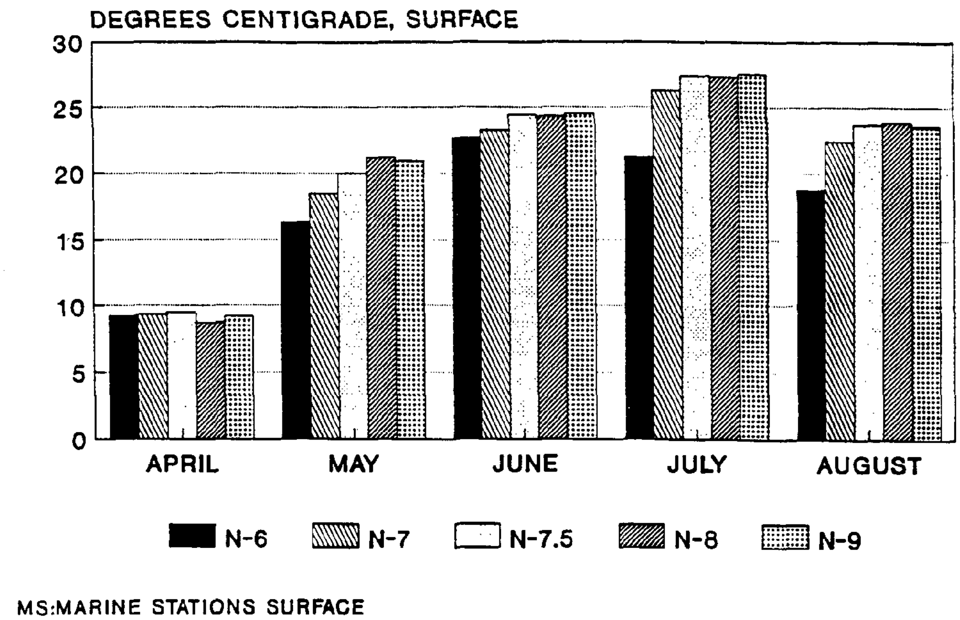


Figure 4-6(a)
TEMPERATURE
Neguntatogue Creek (MS)

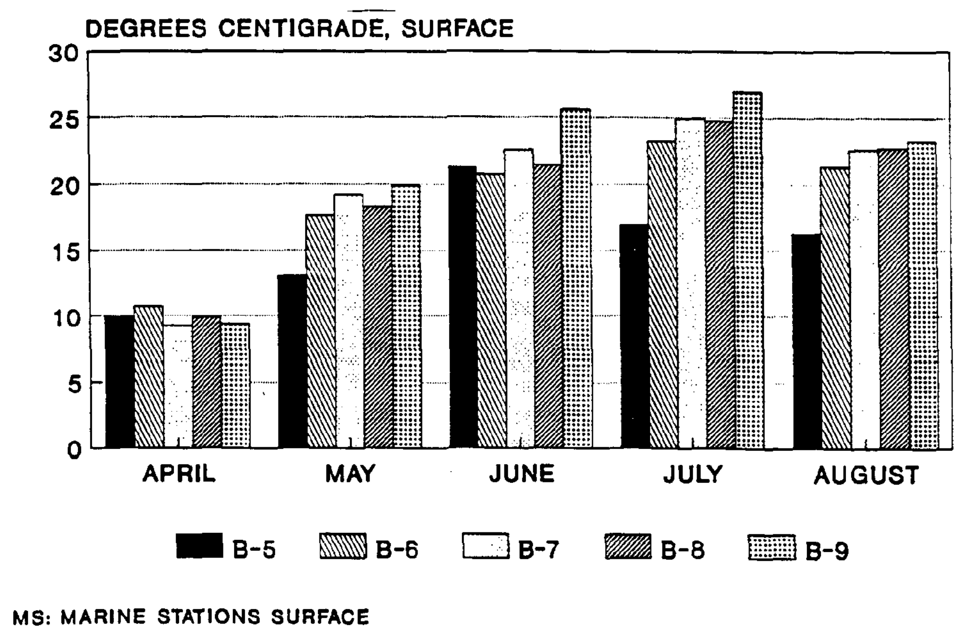


Figure 4-6(b)
TEMPERATURE
Beaverdam Creek (MS)

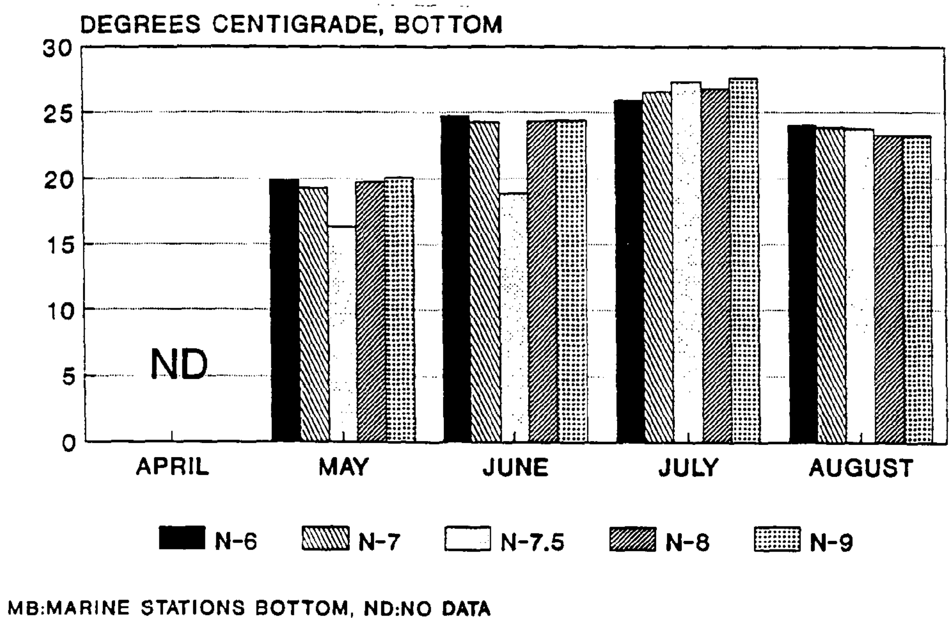


Figure 4-7(a)
TEMPERATURE
Neguntatogue Creek (MB)

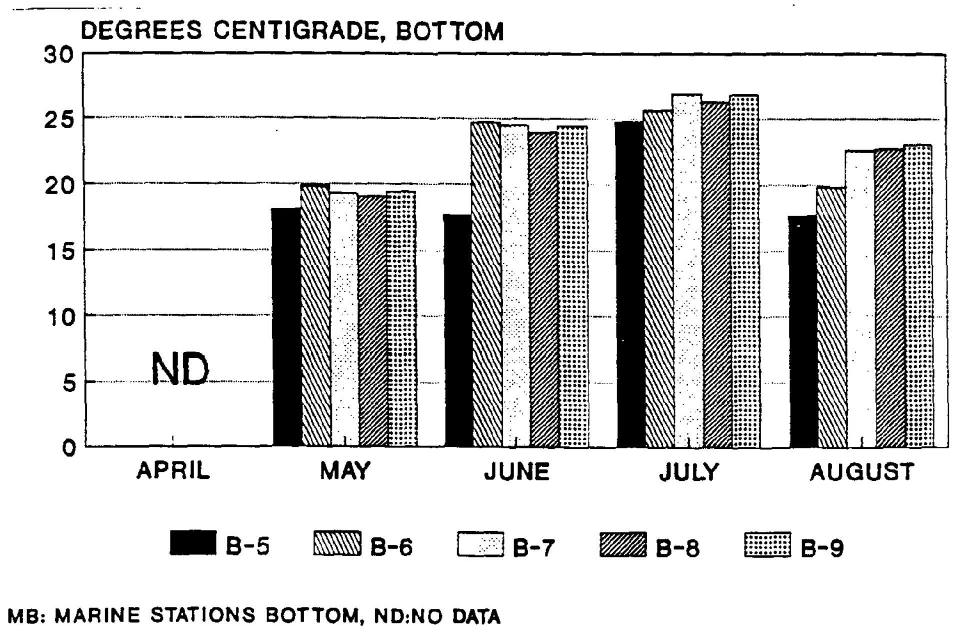


Figure 4-7(b)
TEMPERATURE
Beaverdam Creek (MB)

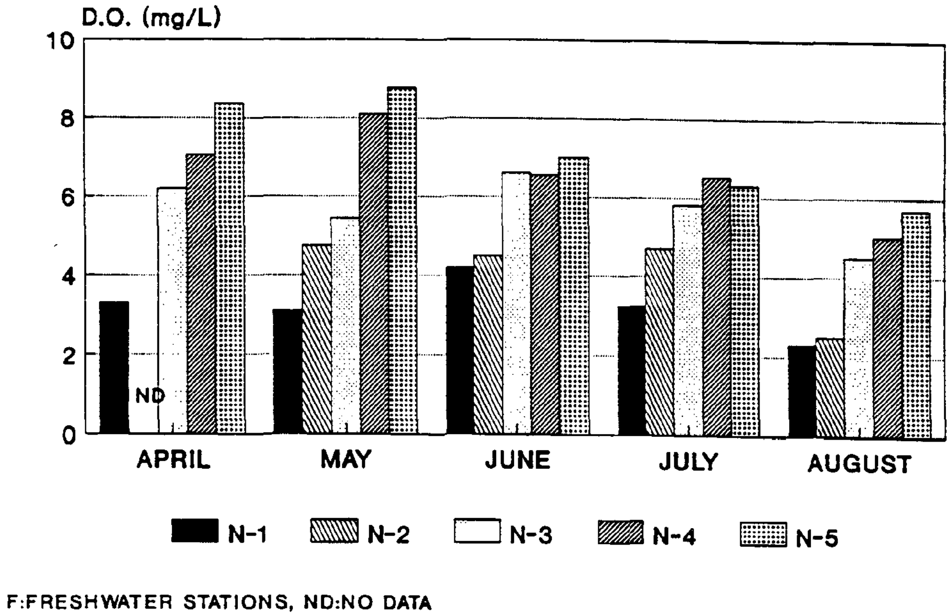


Figure 4-8(a)
DISSOLVED OXYGEN
Neguntatogue Creek (F)

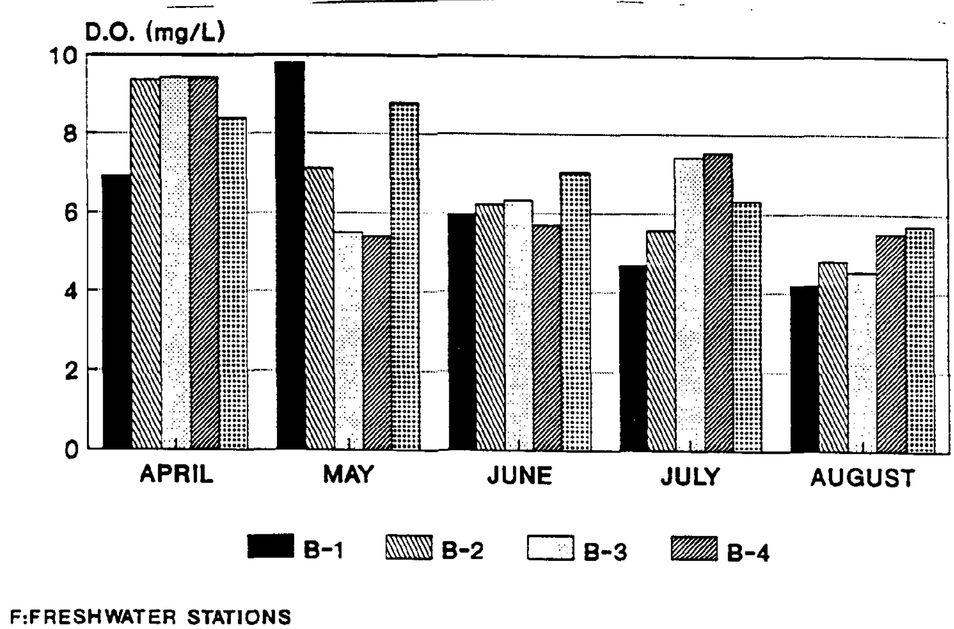


Figure 4-8(b)
DISSOLVED OXYGEN
Beaverdam Creek (F)

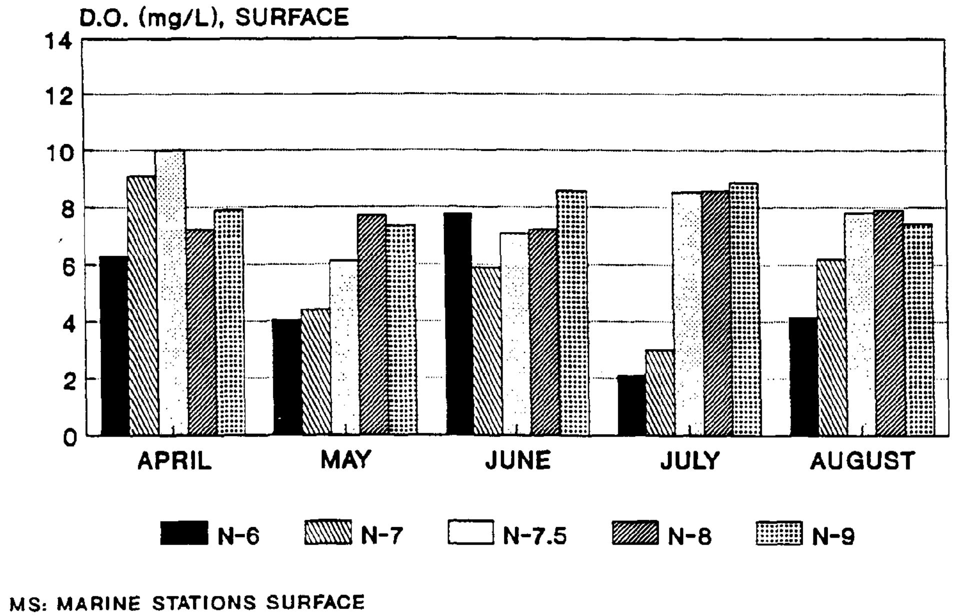


Figure 4-9(a)
DISSOLVED OXYGEN
Neguntatogue Creek (MS)

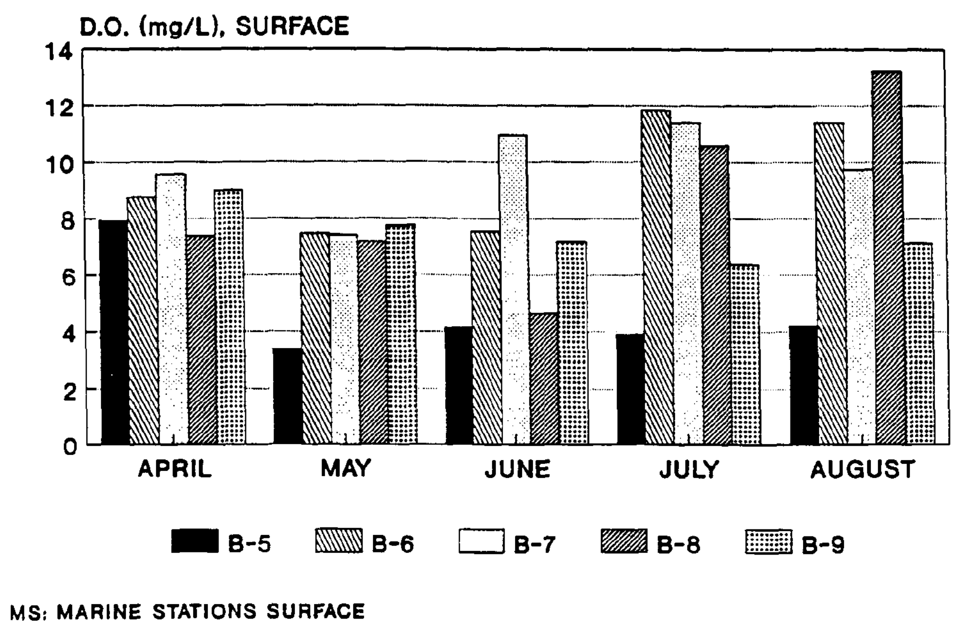


Figure 4-9(b)
DISSOLVED OXYGEN
Beaverdam Creek (MS)

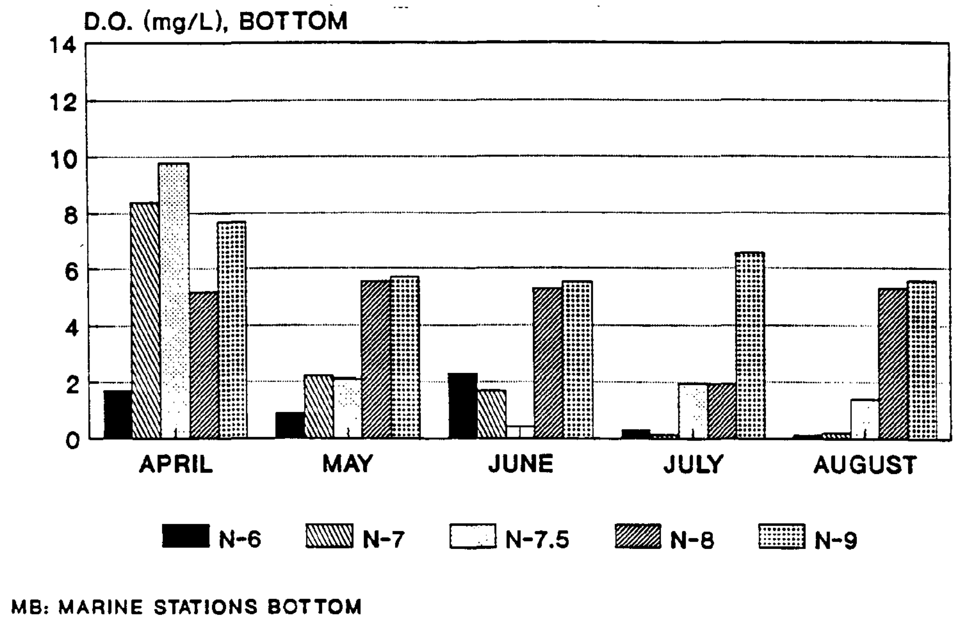


Figure 4-10(a)
DISSOLVED OXYGEN
Neguntatogue Creek (MB)

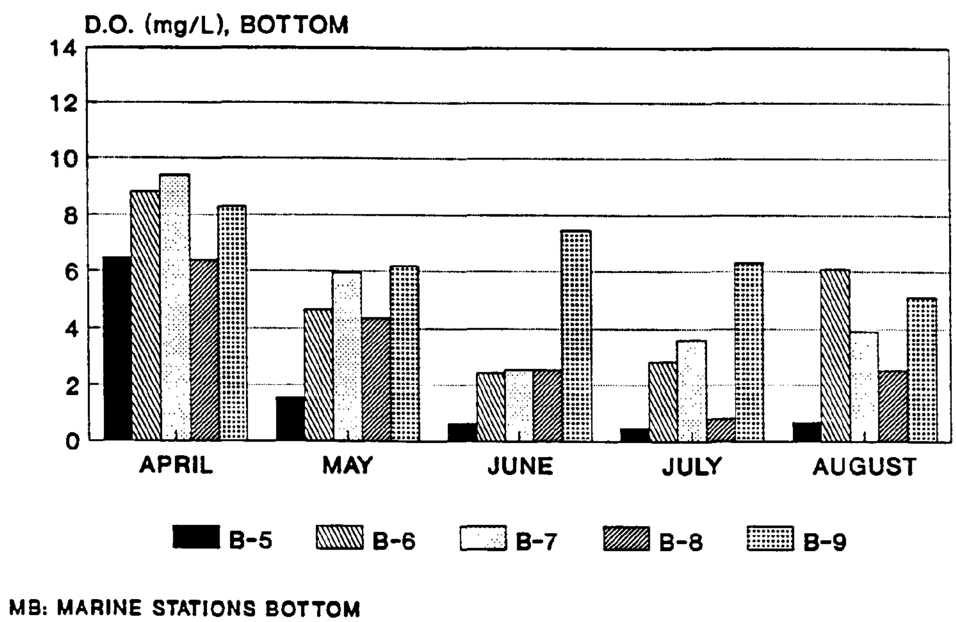


Figure 4-10(b)
DISSOLVED OXYGEN
Beaverdam Creek (MB)

formed in considerable amounts from the action of carbon dioxide (CO_2) upon soils.

Total alkalinity was calculated at all freshwater stations in both Neguntatogue and Beaverdam Creek on each of the five sampling dates. Results are shown in Figure 4-11.

The alkalinity of Neguntatogue Creek was remarkably stable throughout the length of the freshwater portion of the stream and throughout the sampling period. Conversely, alkalinities in Beaverdam Creek varied considerably over the sampling period, averaging 25-35 mg/L in April and May and then increasing in the warmer months to as high as 130 mg/L at station B1. Moreover, the alkalinity of Beaverdam Creek clearly decreases from the northerly to the more southerly stations.

Data from the FANS Study (Suffolk County Executive Office: Special Projects 1980) show significantly lower total calcium carbonate alkalinities than those observed in the present study. The range observed in July 1978 was 15-31 mg $CaCO_3$/L, in contrast to a range of 72-85 mg/L found in this study. No explanation is readily apparent to account for this apparent increase in alkalinity of the Creek's waters. Alkalinities from groundwater samples in the vicinity of the Creek ranged from 18 - 169 mg $CaCO_3$/L, however.

4.4.5 pH

pH is a term universally used to express the intensity of the acid or alkaline condition of fresh and marine waters. It is a way of describing the activity of the hydrogen ion. All freshwater and marine organisms have pH tolerance ranges, waters of a pH outside this range being intolerable to these species for any length of time. The carbonic acid system of the ocean provides a significant buffering system against pH variations in the sea, which in open ocean waters rarely fall outside the range 7.8-8.2. Freshwaters are much more likely to have wide variability in pH.

Data on pH from the two streams are shown in Figures 4-12 to 4-14. There is little difference in the pH characteristics of Beaverdam and Neguntatogue Creeks.

4.4.6 Streamflow

Measured streamflow data is shown in Table 4-2. As expected, streamflow is highly variable between the two creeks and between sampling dates within a single creek. These limited data suggest that streamflow in Beaverdam Creek is somewhat less variable than the flow in Neguntatogue Creek. None of the streamflow measurements were made during active rainfall events, when the creeks would be subject to large volumes of direct overland runoff. Scour marks and windrows of debris, particularly along Neguntatogue Creek, suggest that intense rainstorms can produce flows in both streams very much in excess of those reported here.

TABLE 4-2

Streamflow (cfs), Neguntatogue & Beaverdam Creeks

Station	*04/07/89*	*06/25/89*	*07/27/89*
N4	0.53	8.80	2.06
N5	0.55	17.67	4.06
B2	1.32	1.20	1.37
B3	2.89	6.57	5.62

The lowest streamflow of the three sampling dates was in April. This is curious as, of the three sampling dates, only the April sampling was preceded by significant rainfall, daily precipitation at a National Weather Service recording station in Islip averaging nearly 0.25 inches during the period 04-06 April 1989.

Similarly, greatly increased flows were recorded in Neguntatogue Creek on 06/25, when no significant precipitation had occurred anywhere on Long Island for the prior three days. The flow of 2.06 cfs recorded at station N4 on 07/27 compares well with historic data for dry weather baseflow from the same location. Stream station 5-6 of the Neguntatogue Creek report of the FANS Study (Suffolk County-Executive Office: Special Projects 1980) indicates an average flow at this point in the creek during June - September of 2.01 cfs. At the southernmost station of the freshwater reach of Neguntatogue Creek (Station N5), the flow value of 4.06 cfs likewise is consistent with flow data at FANS station 5-9, which averaged 3.96 cfs during the period June - September, 1978.

4.4.7 Nutrients

The amount and type of nutrients in natural waters influence the abundance and composition of the phytoplankton community. Phytoplankton multiply by taking up dissolved nutrients in the presence of light during photosynthesis. Nutrients can be either inorganic or organic compounds. The most important factors contributing to primary production of phytoplankton are light and nutrient availability (Raymont 1980). Among the inorganic nutrients most important for primary production are nitrate, nitrite, ammonia, and phosphate. Nutrients are often contributed in excess to an aquatic system as a result of human activities.

Nutrient analyses of surface waters of the two streams are shown in Figures 4-15 and 4-16. Several nutrient samples from Beaverdam Creek were contaminated by an unknown flocculating agent and had to be destroyed. The U.S. Geological Survey recently conducted a survey of groundwater and surface water quality in the freshwater reaches of Beaverdam Creek and provided data on nutrient levels in this portion of the Creek.

Ammonium levels in Beaverdam Creek (Figure 4-15) are well within normal except for a high pulse of ammonium at station B6 in June. This could be a consequence of fertilizer runoff from a farm adjacent to the Creek; ammonium salts are a principal component of agricultural fertilizers. In Neguntatogue Creek, stations N3 and N6 show extremely high levels of ammonium for all three months. The bay station (N9) has normal levels of ammonia throughout the sampling period. Station N3 is Feller's Pond in the municipal park and the presence of an abundant waterfowl population is the most likely explanation of the high ammonium levels at this station.

The levels of nitrate and nitrite from the present study show a pattern very similar to that of ammonium (Figure 4-15). June and August nutrient samples from station B3 in Beaverdam Creek were contaminated and had to be discarded. However, recent data collected in the freshwater portion of Beaverdam Creek at a station near Montauk Highway by the U.S. Geological Survey in Fall 1989 reveal nitrate levels of approximately 10 µg-at/L, similar to levels found at our station B3 in April 1989. However, where ammonium levels at station B3 in April were approximately 4 µg-at/L, the USGS found ammonium levels of approximately 550 µg-at/L. The USGS data were taken as part of a study by the Town of Brookhaven to examine the influence of leachate on Beaverdam Creek from the Town of Brookhaven Landfill on Horseblock Road. The landfill is located less than a mile northwest of the headwaters of the Creek. Such elevated ammonium levels, apparently taken during dry, baseflow conditions (Steven Feldman pers. comm.), may indicate the contamination of the surface waters of the upper reaches of the Creek with leachate from the landfill. Orthophosphate concentrations (Figure 4-16) in the two streams appear to be within normal ranges. The relatively high elevation in phosphate at station B6 in June may be an effect of fertilizers from the adjacent active farm. This enrichment of phos-

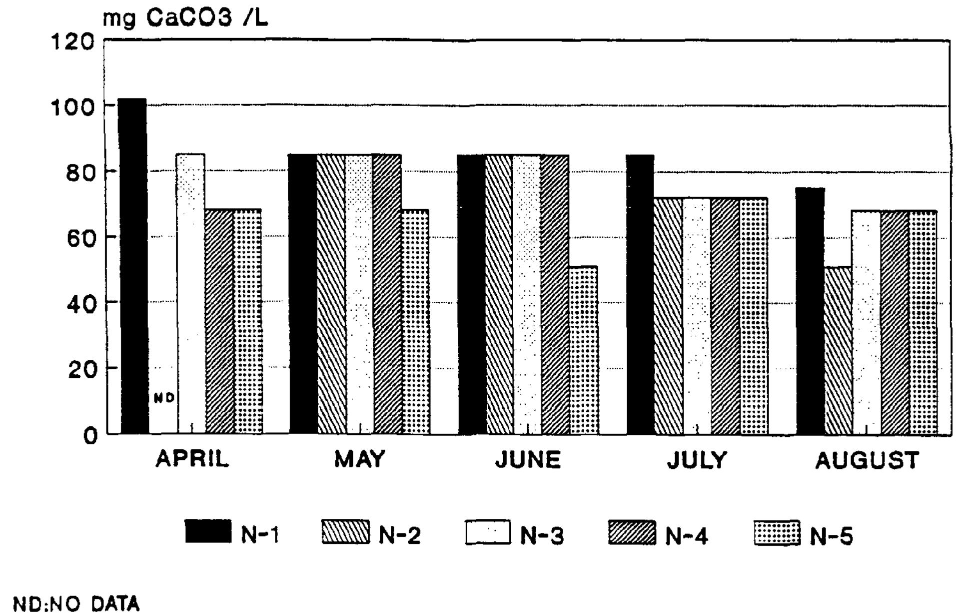


Figure 4-11(a)
ALKALINITY
Neguntatogue Creek

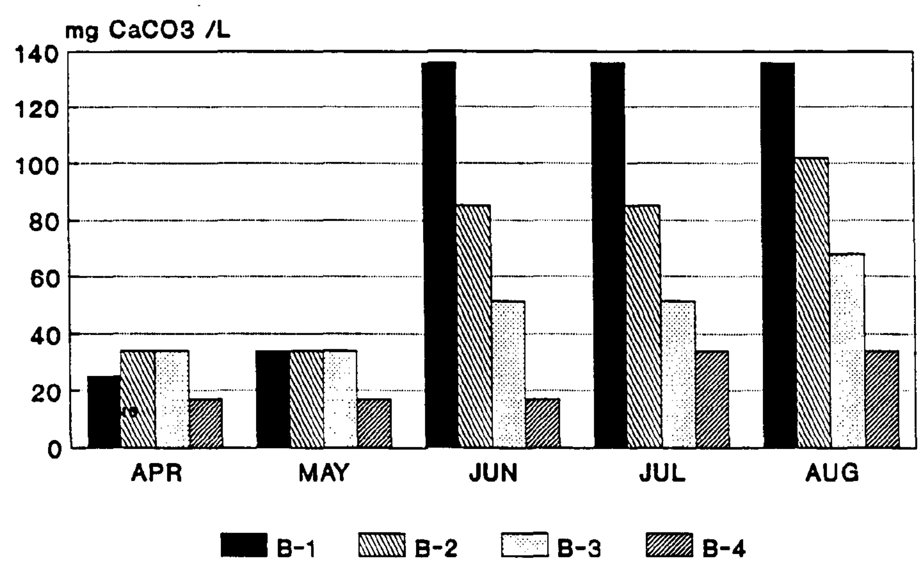


Figure 4-11(b)
ALKALINITY
Beaverdam Creek

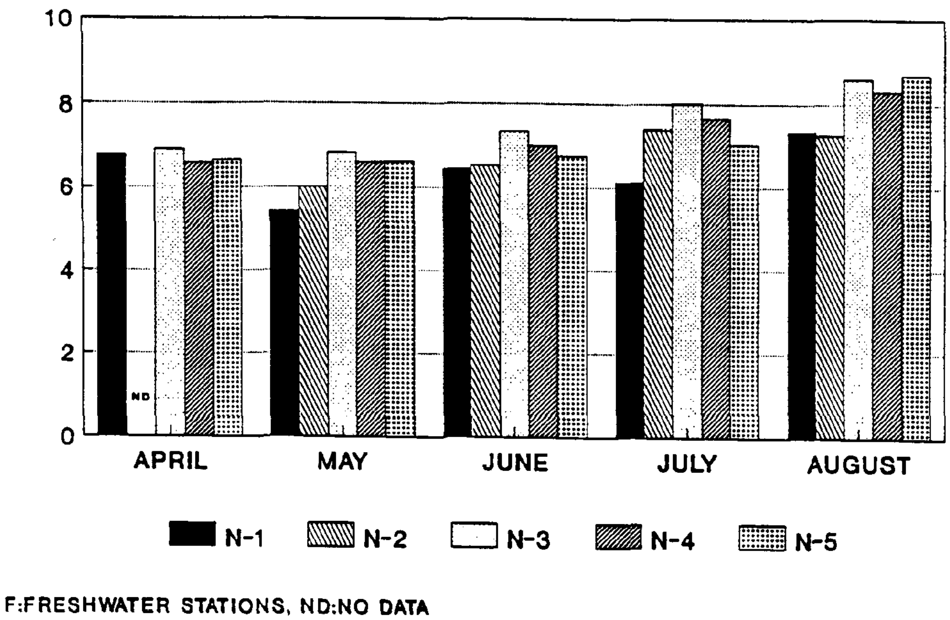


Figure 4-12(a)
pH
Neguntatogue Creek (F)

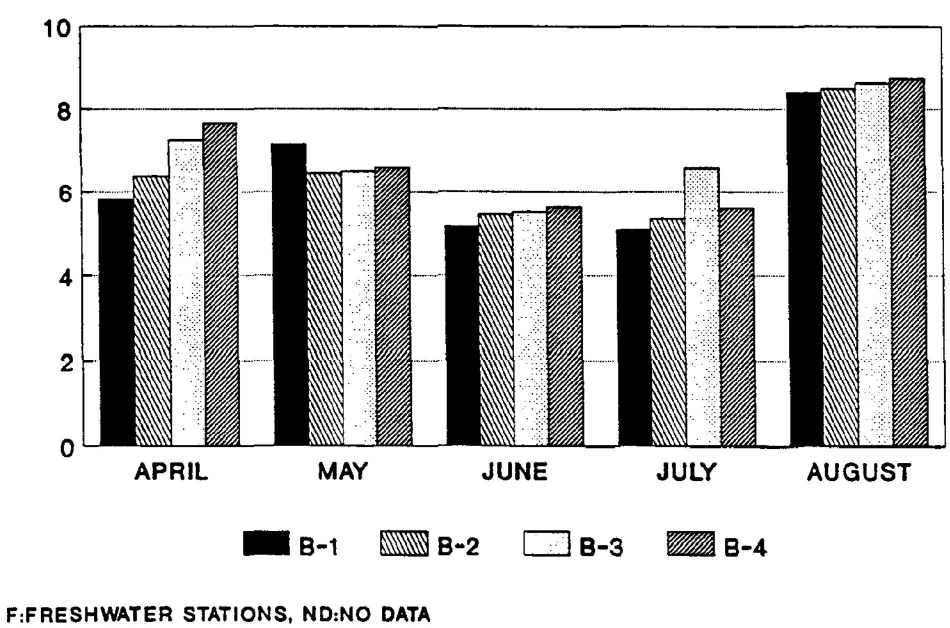


Figure 4-12(b)
pH
Beaverdam Creek (F)

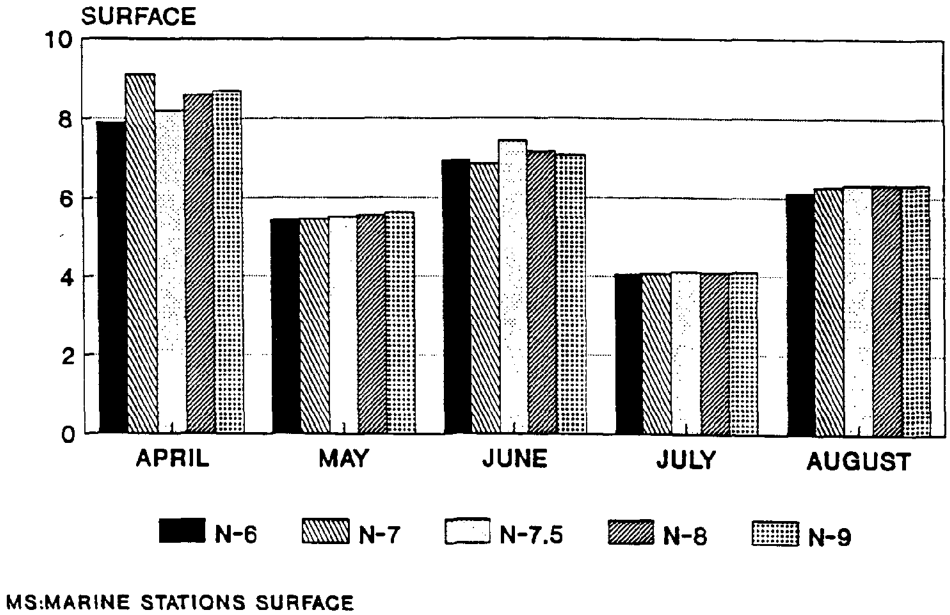


Figure 4-13(a)
pH
Neguntatogue Creek (MS)

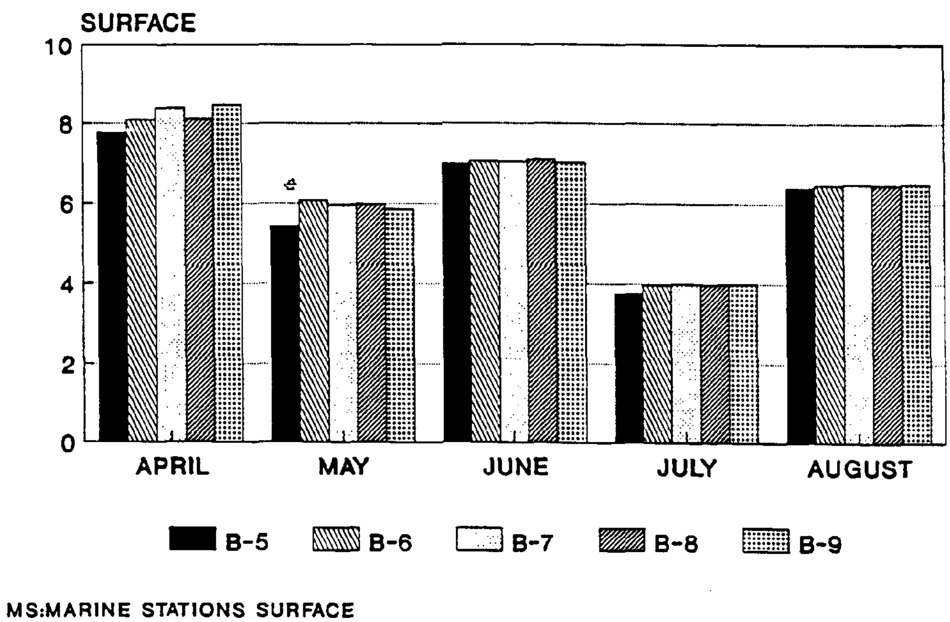


Figure 4-13(b)
pH
Beaverdam Creek (MS)

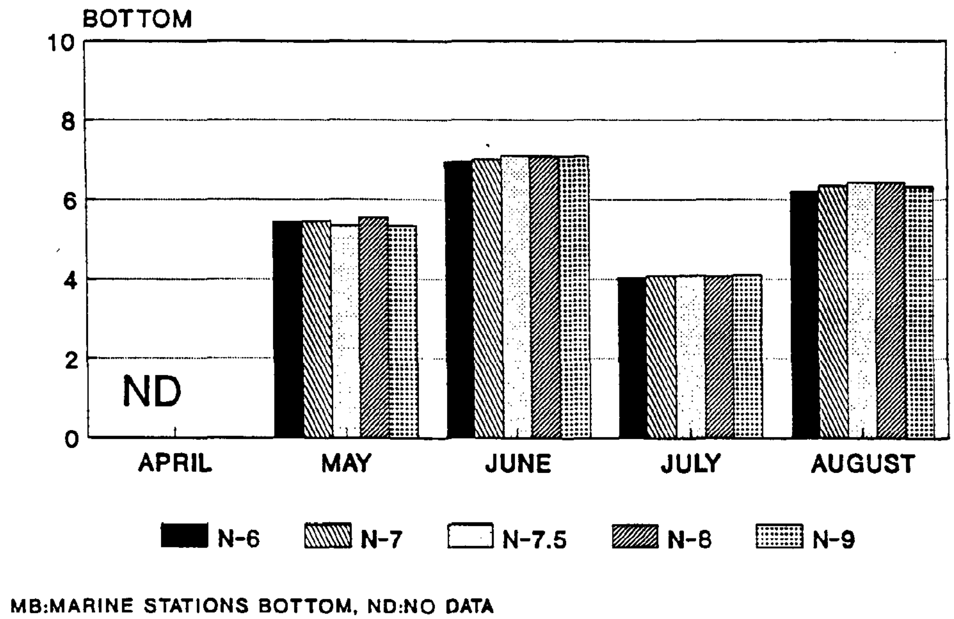


Figure 4-14(a)
pH
Neguntatogue Creek (MB)

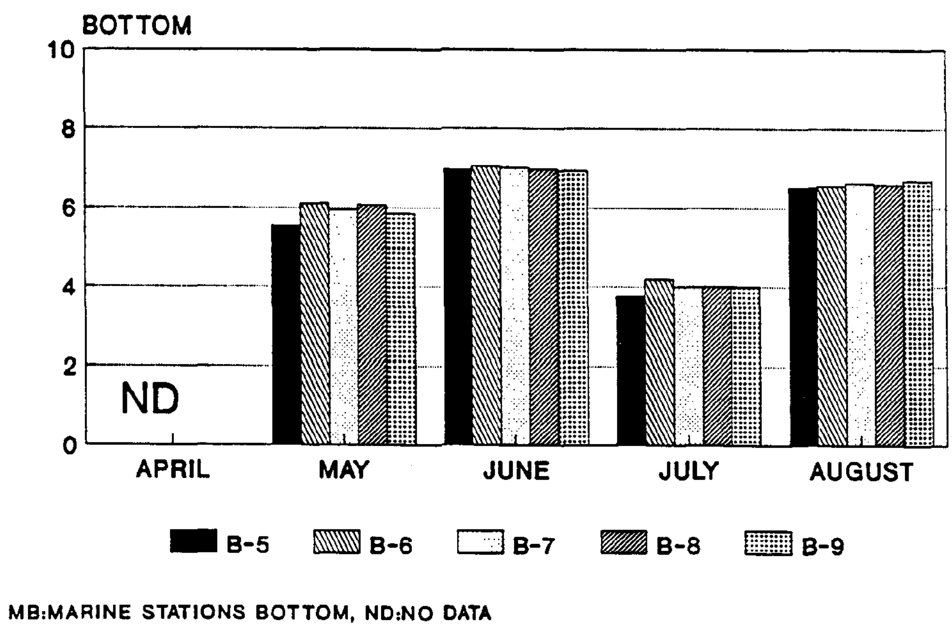


Figure 4-14(b)
pH
Beaverdam Creek (MB)

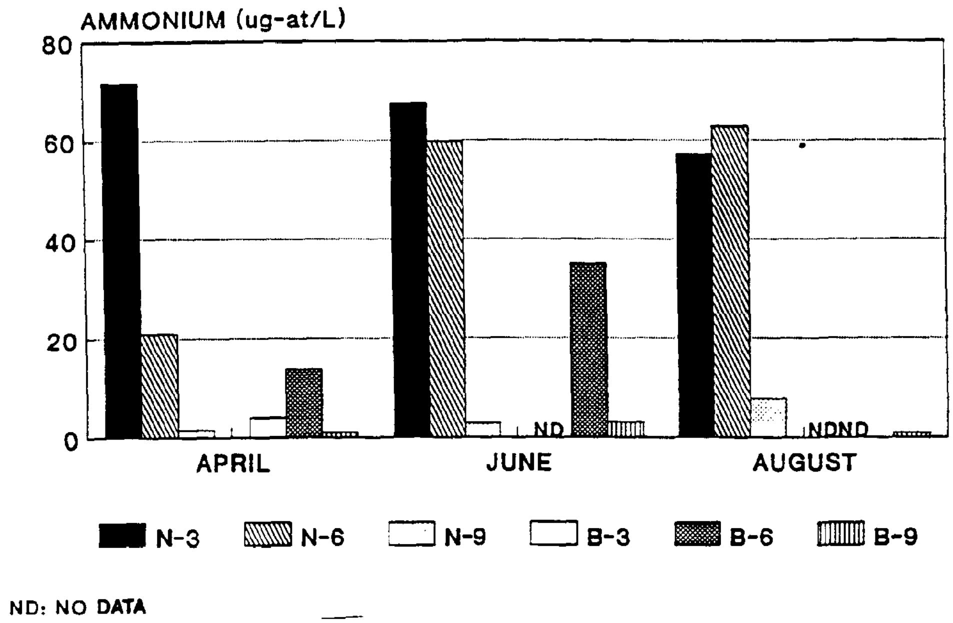


Figure 4-15(a)
AMMONIUM
Neguntatogue and Beaverdam Creeks

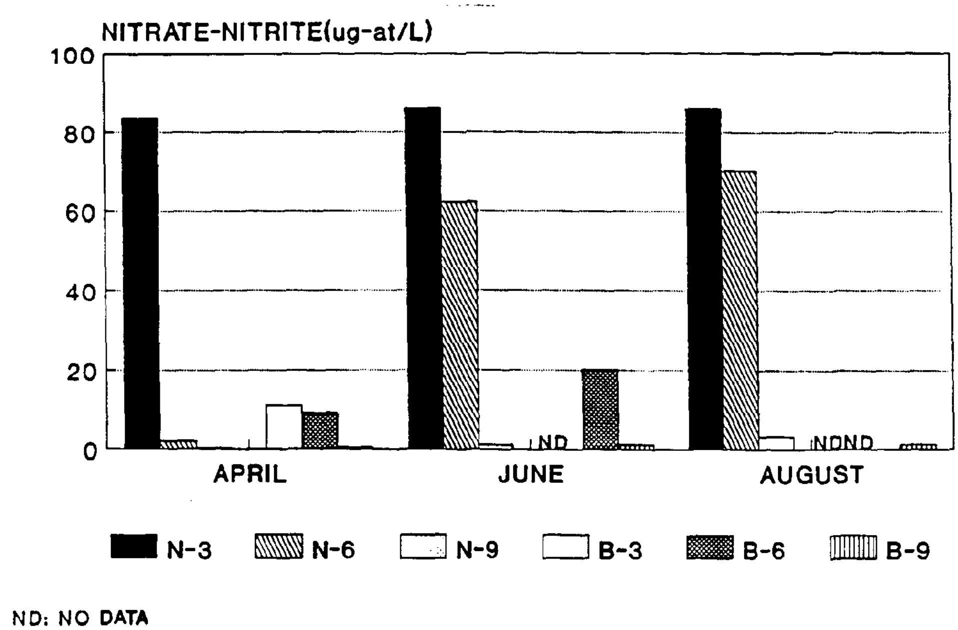
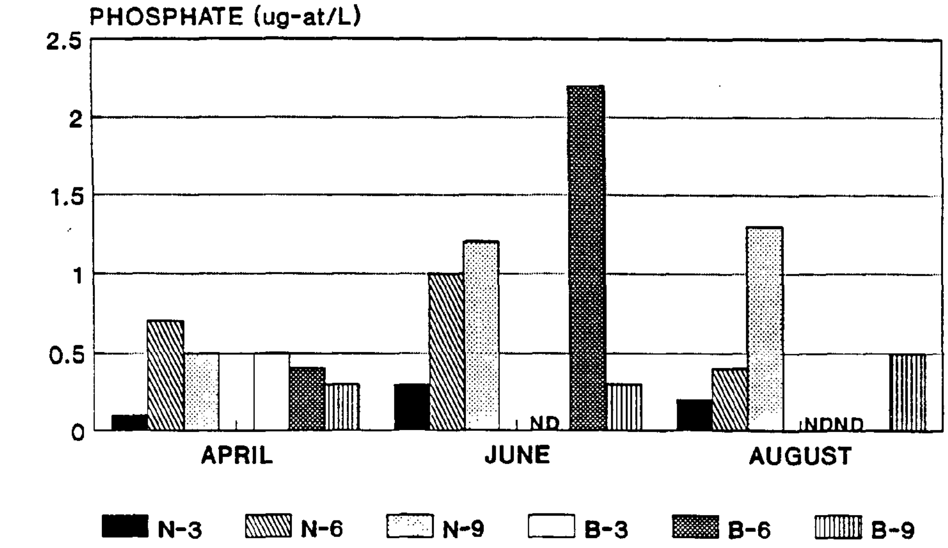


Figure 4-15(b)
NITRATE-NITRITE
Neguntatogue and Beaverdam Creeks



ND: NO DATA

Figure 4-16(a)
PHOSPHATE
Neguntatogue and Beaverdam Creeks

phate may have triggered the phytoplankton bloom occuring at this station and stations B7 and B8 at this time .

4.4.8 Chlorophyll a

With the exception of station N3 in August, chlorophyll a values from the freshwater reaches of Neguntatogue Creek were slightly higher than the values from the freshwater reaches of Beaverdam Creek (Figure 4-17). Station N3 is Feller's Pond on Neguntatogue and the August value suggests a temporary phytoplankton bloom. The freshwater stations in Beaverdam Creek have very low levels of chlorophyll, probably attributable to the low retention of phytoplankton due to flushing. Chlorophyll a values from the marine portion of Neguntatogue Creek (Figure 4-18) were well below the values in Beaverdam Creek and showed a steady increase in a seaward direction. Neguntatogue Creek chlorophyll a values are consistent with the normal range of chlorophyll a concentrations in local waters under non-bloom conditions. Chlorophyll values in Beaverdam Creek did not show an increasing trend towards the Bay; station B8 was consistently characterized by extremely high chlorophyll values beginning with the May sampling.

No consistent patterns appear between chlorophyll a values in July (relative drought) and August (immediately after heavy rainfall).

4.4.9 Phytoplankton Community

Phytoplankton distribution and abundance showed considerable spatial and temporal variability during the study. Table 4-3 presents the abundances of major components of the phytoplankton during April, June, and August. In both Beaverdam and Neguntatogue Creeks, stations N3 and B3 clearly displayed a freshwater flora during the April, June, and August samplings. These stations were dominated by small coccoid nanoplankton and various microflagellates with occasional blooms of the diatom *Rhizoselenia eriensis*, a cryptomonad species, and several chrysophycean flagellates. Stations B6, B9, N6, and N9 contained a marina flora. Small nanoplankton and microflagellates numerically dominated all samples except for N6 and N9 during June. In April, diatoms were the most abundant netplankton component with the chain-forming species *Chaetoceros socialis*, *Rhizoselenia delicatula*, and *R. fragilissima* abundant. Large flagellates were generally unimportant except for small local blooms of *Katodinium rotundatum* at N9 and cryptomonads at B9. June samples (N6 and N9) were remarkable for high abundances of the small diatom *Minutocellus spp.*

The June B6 netplankton was dominated by an unidentified green flagellate and a large dinoflagellate similar to *Gymnodinium sangineum*. By August, the flora had shifted slightly with large numbers of the small diatom *Cyclotella* spp. present at B9. *Gymnodinium* continued to occur at high numbers at B6. Phytoplankton abundances had decreased considerably at N6, but *Minutocellus* continued to dominate at N9 although at much lower abundances than in June. Co-dominants included the diatoms *Cyclotella* spp. and, curiously, the freshwater species *Rhizoselenia eriensis*.

4.4.10 Sediment Grain Size and Organic Content

Information on grain size and loss on ignition of the sediments of Neguntatogue and Beaverdam Creeks is found in Figure 4-19 and Appendix Table A-10.

The substrate in the freshwater reaches of both streams is primarily composed of sand and gravel, reflecting the higher water velocities present in these reaches. Bottom sediments of the marine reaches in both streams contain primarily silty sand, except for stations B5 and B6, where the sediments have a much higher percentage of silt and clay. As expected, the loss on ignition data *track* the relative percentage of silt and clay quite closely; the most organic sediments (approximately 50% by weight) were those from stations B4 and B5, clearly indicating a depositional environment.

TABLE 4-3

Phytoplankton (cells/ml)

Species Group	*Abundance At Each Station*					
	N3	N6	N9	B3	B6	B9
APRIL 1989						
Diatoms	61	1015	7777	94	965	4143
Chlorophytes	12			284		
Euglenoid Flagellates	21			8		
Chrysophytes	41			4	100	
Dinoflagellates	8	10	1210		7	20
Cryptomonads	4		62		24	1260
Coccoid nanoplankton	153332	16667	52222	11111	62222	52222
Microflagellates	74444	44444	408884	33333	34444	52222
JUNE 1989						
Diatoms	48	66700	434440	51	5692	1172
Chlorophytes	184	20			3814	21
Euglenoid Flagellates	21			3		
Chrysophytes	515	272				33
Dinoflagellates	371		144		3340	422
Cryptomonads	1194	10	103			280
Coccoid nanoplankton	31111	34444	91110	19999	32221	131110
Microflagellates	1244443	24444	91110	15555	84444	21111
AUGUST 1989						
Diatoms	8888	376	10671	21	21	26574
Chlorophytes	41	69		54		
Chrysophytes	61235	7	31	4		
Dinoflagellates		192	30		13333	
Cf. microcystis sp.	855	268				
Coccoid nanoplankton	55555	12222	51111	26666	168887	651104
Microflagellates	64444	6666	46662	13333	93332	64444

Observation suggests that most of the organic material in Beaverdam Creek was terrestrial in origin (leaf litter, roots, etc.); organic material in Neguntatogue Creek sediments was partly terrestrial, but included significant amounts of decaying eelgrass.

The low loss on ignition values for the two open Bay stations (N9/B9) are representative of historic values for Great South Bay. It is unclear the extent to which Beaverdam and, particularly, Neguntatogue Creek is a significant source of organic detritus to the main body of the Bay.

4.4.11 Sediment Metals

Results of the sediment metal analyses for both streams is shown in Table 4-4. Sediments in the freshwater reaches of each stream have much lower levels of the metals tested than do sediments in the marine reaches. The metal content of Neguntatogue Creek sediments is generally much higher than that of Beaverdam sediments; for copper and lead in upstream sections of both freshwater and marine reaches, this difference is often an order of magnitude or

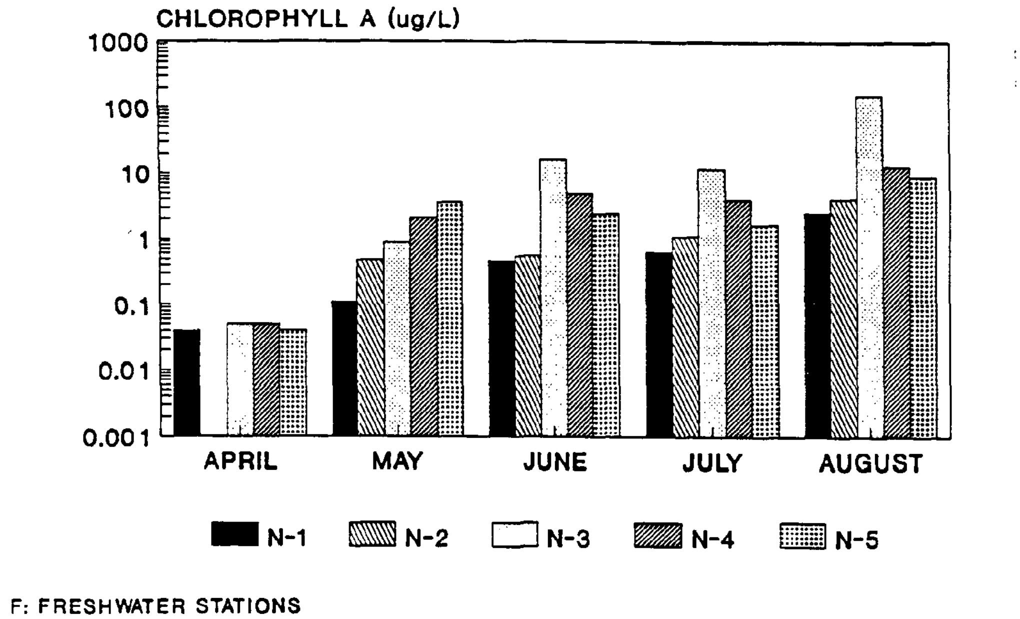


Figure 4-17(a)
CHOROPHYLL a
Neguntatogue Creek (F)

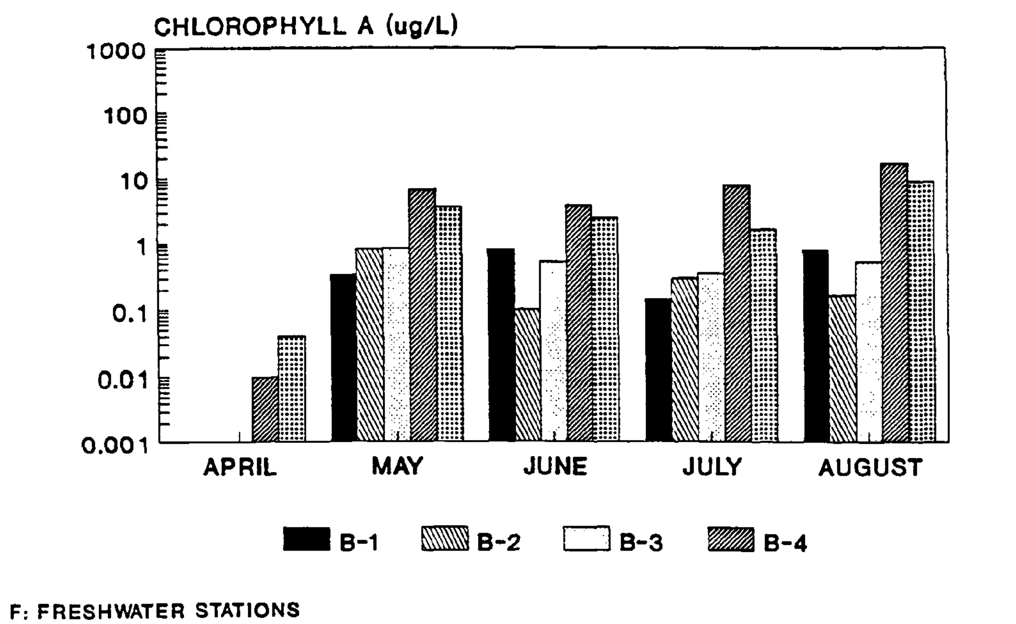


Figure 4-17(b)
CHOROPHYLL a
Beaverdam Creek (F)

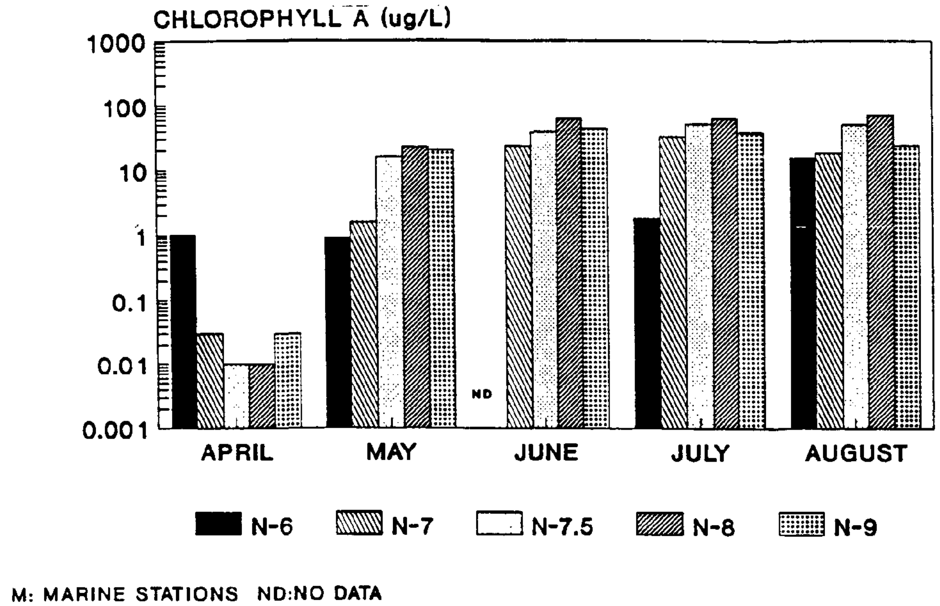


Figure 4-18(a)
CHLOROPHYLL a
Neguntatogue Creek (M)

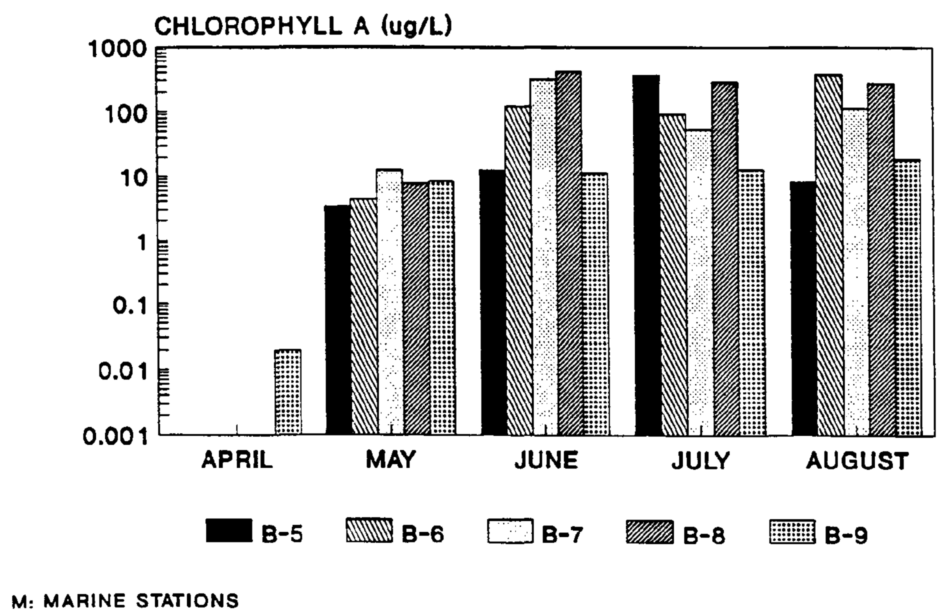
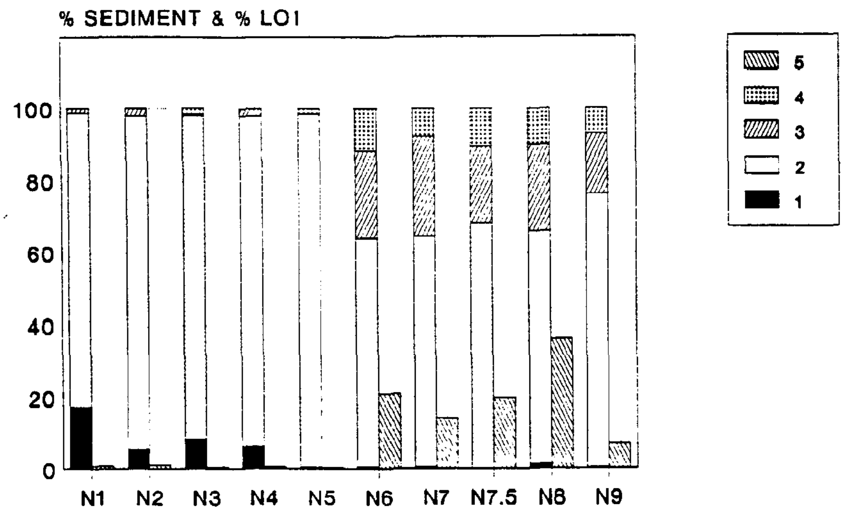
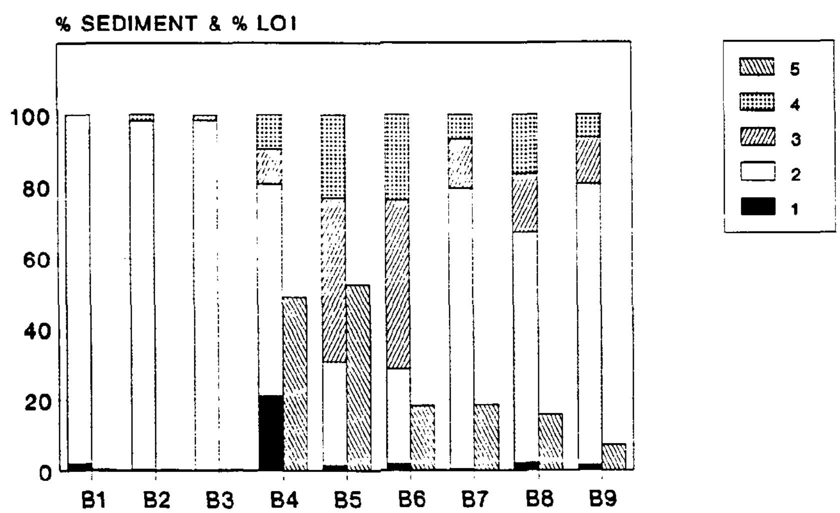


Figure 4-18(b)
CHLOROPHYLL a
Beaverdam Creek (M)



1 = GRAVEL: 2 = SAND: 3 = SILT; 4 = CLAY; 5 = LOSS ON IGNITION;

Figure 4-19(a)
SEDIMENT GRAIN SIZE and LOSS ON IGNITION
Neguntatogue Creek



1 = GRAVEL: 2 = SAND: 3 = SILT; 4 = CLAY; 5 = LOSS ON IGNITION;

Figure 4-19(b)
SEDIMENT GRAIN SIZE and LOSS ON IGNITION
Beaverdam Creek

TABLE 4-4
Sediment-associated Metals (ppm)

Station	Cu	Pb	Zn	Mn
N1	5	23	71	79
N2	5	7	67	33
N3	2	5	20	221
N4	5	2	18	123
N5	5	2	5	94
N6	444	671	506	305
N7	420	286	374	211
N7.5	275	169	330	291
N8	172	61	363	76
N9	15	23	55	394
B1	1	1	2	52
B2	1	1	4	81
B3	2	1	1	40
B4	5	72	19	88
B5	10	67	113	161
B6	51	61	139	338
B7	27	23	110	221
B8	96	56	156	265

more. The data for manganese do not follow the trends displayed by the other metals. the highest levels being found in the open Bay station sediments south of each stream. Manganese is a relatively abundant trace metal in marine sediments and the observed distribution is not surprising.

Within both the freshwater and marine reaches of Neguntatogue Creek, the levels of all metals other than manganese decrease as one moves downstream and into the open Bay waters, with the exception of a rise in the level of zinc at station N8. The same pattern of decreasing metal concentration in the downstream direction is generally found in Beaverdam Creek sediments, with the exceptions of stations B4 and B8 and a slight rise in zinc concentration at station B6.

The sediments of Neguntatogue Creek are greatly enriched in metals compared to levels found in the open waters of Great South Bay and other waterbodies around Long Island. For example, Behrens (1978) found the following metal concentrations in sediments in the Great South Bay southeast of Awixa Creek, near the Islip/Brookhaven town line: Cu = 1.9 ppm; Pb = 4-5 ppm; Zn 13-15 ppm. Elevated sediment metal concentrations are found in the Throgs Neck area of Long Island Sound: Cu = 258 ppm; Pb = 210 ppm; Zn = 291 ppm (Greig 1977). For comparative purposes, Benninger et al. (1979) estimated the background, pre-industrial concentration of Cu in Long Island Sound at 9-17 ppm, Zn at 73-85 ppm, and Pb at 17-21 ppm.

In an examination of levels of metals in the surficial sediments of several streams feeding into the Great South Bay, David Hirschberg (pers. comm.) found average lead concentrations of approximately 180 ppm with copper values of approximately 60 ppm. Coring data from open Great South Bay waters suggest basal, preindustrial levels of lead and copper of < 10 ppm.

The elevated concentrations of metals in the sediments of Neguntatogue Creek prompted a subsequent analysis of the levels of metals in the water column of the freshwater reaches of the creek, to help assess the importance of downstream transport into the marine reaches as a source of metals into the marine sediments. Water column levels of the four metals assayed are shown in Table 4-5.

4.4.12 Ambient Water Bioassay

Results of the ambient water bioassay tests are shown in Table 4-6. Only the undiluted (100%) samples from both creeks produced mortalities above the 10% threshhold considered acceptable in control organisms and indicating significant acute toxicity to experimental organisms.

The freshwater Neguntatogue Creek station appears to present somewhat greater acute toxicity than the freshwater Beaverdam Creek station, particularly for finfish. Conversely, the Beaverdam Creek marine station appears to present somewhat greater acute toxicity than the Neguntatogue Creek marine station; again, this is particularly so for finfish. Our finding of lower mortalities of invertebrate test animals than of finfish is frequently observed in ambient water bioassays (T. Cosper pers. comm.). The temporal variability in mortalities observed in these tests indicates that the toxic agent(s) operating in the spring may not be the same as those impacting these two streams later in the year. Unexpectedly, August water samples produced relatively low mortality for freshwater organisms. Conversely, for the mysid shrimp, August produced the highest mortality. The reasons for this, and its possible significance, are unknown.

TABLE 4-5
Water Column Metals (ppb)

Station	Cu	Pb	Zn	Cd
N2	0.01	5.32	98.60	0.83
N5	0.02	0.51	63.00	0.77
B2	0.00	1.19	30.80	0.39
B4	0.03	0.12	22.00	0.55

TABLE 4-6
Ambient Water Bioassays

Station	Organism	% Mortality		
		April	June	August
N4	*Pimephales promelas*	50	20	10
B3	*Pimephales promelas*	30	10	0
N4	*Ceriodaphnia dubia*	0	20	0
B3	*Ceriodaphnia dubia*	15	0	5
N6	*Cyprinodon variegatus*	0	30	0
B8	*Cyprinodon variegatus*	0	50	25
N6	*Mysidopsis bahia*	10	0	20
B8	*Mysidopsis bahia*	5	10	15

The 50% mortality of fathead minnows in April N4 water occurred when dissolved oxygen levels in the experimental chamber remained above 7.0 mg/l throughout the 96-hour exposure; the similar mortality of sheepshead minnows in June B8 water occurred over a 96-hour test during which the dissolved oxygen in the chamber dropped after 48 hours to 4.0 mg/l but subsequently rose to above 5.0 mg/l. This temporary decline in oxygen concentrations may have imposed additional stress on experimental animals and contributed to the observed mortalities.

4.4.13 Benthic Macrofauna

SPECIES COMPOSITION - From 57 samples (19 on each sampling date from both creeks), 40 benthic taxa were obtained. Complete benthic data from each sampling date for each creek are found in Appendix Tables A-11A to A-11C. These 40 taxa were composed of 17 polychaetes, 14 crustaceans, 4 bivalves, 2 oligochaetes, 1 hydrozoan, and 2 insect larvae from the freshwater reaches of the streams.

Tubificid worms were the dominant benthic organisms at all freshwater stations in both Beaverdam Creek and Neguntatogue Creek; in the latter, they were the only taxon found at any of the freshwater stations. At Beaverdam Creek freshwater stations, various crustaceans (amphipods, ostracods, isopods) and insect larvae were also present except during the August sampling.

In May, the polychaete worm *Capitella capitata* and the bivalve *Spisula solidissima* were dominant at the marine stations in Beaverdam Creek, while dominant organisms at the marine stations of Neguntatogue Creek included the amphipod *Ampelisca abdita* and the polychaete worms *Scoloplos acutus*, *Polydora ligni*, and *Capitella capitata*. By July, the polychaete worms *Clymanella torquata*, *Pectinaria gouldii*, and *Terebellidae spp*. were dominant at the marine stations in Beaverdam, while *Ampelisca abdita* remained the most abundant organism in the marine section of Neguntatogue Creek. During September, *Nereis arenaceodonta* along with other, unidentifed polychaete worms were present at the marine stations in Beaverdam Creek, but overall abundances were low at this time. The amphipod*Ampelisca abdita* remained dominant in Neguntatogue Creek.

ABUNDANCE - The spatial and temporal patterns in total abundance of benthic animals in each creek are shown in Figures 4-20 and 4-21. Abundances ranged from 0 to 42,959 individuals/m^2. Generally, total benthic abundance at the freshwater stations was higher than at the marine stations in each stream. As noted above, the abundances at freshwater stations generally reflect the presence of a single taxon, oligochaete worms. Because Neguntatogue Creek had significantly consistently higher abundances of this organism, its composite benthic abundance is higher than that of Beaverdam Creek. No benthic organisms were found at three of the marine stations in Neguntatogue Creek (N6, N7, N7.5) at any time. The lower marine stations of Beaverdam Creek also displayed an impoverished benthic fauna, although richer than that of Neguntatogue Creek. At the open bay stations off the mouths of both creeks (N9 & B9), benthic abundances were relatively high (83 to 11,154 organisms/m^2), compared to the creeks proper, throughout the study period.

SPECIES RICHNESS - Spatial and temporal patterns in the species richness of Neguntatogue and Beaverdam Creeks are shown in Figures 4-22 and 4-23. The number of species at each station ranged from 0 to 20. Generally, maximum species richness was found at the two open bay stations, with significantly fewer numbers of species found at both the freshwater and marine stream stations. On balance, benthic species richness was higher in Beaverdam Creek than in Neguntatogue Creek, except at the open bay stations, N9 and B9.

SPECIES DIVERSITY - Spatial and temporal patterns in the species diversity of each creek are shown in Figures 4-24 and 4-25. The Y axis of the plot shows the value of the species diversity + 1, in order to avoid the confusion between a species diversity of 0 due to the presence at a station of only a single species and the meaningless value of 0 for species diversity at a station where the benthic abundance was also 0. Species diversity values ranged from 0 - 0.79, with the higher values generally found in Beaverdam Creek.

4.4.14 Bacterial Contamination

The results of the coliform bacteria assay of each stream are shown in Table 4-7. The statistical variability of the three-tube test for coliform bacteria is inherently quite high, producing widely differing abundances from replicates at a single station. The State of New York uses the following standards for determining waters certified for harvesting shellfish for consumption:

- total coliform median shall not exceed 70 per 100ml of water and not more than 10% of the samples exceed 230 per 100ml.
- fecal coliform median shall not exceed 14 per 100ml of water and not more than 10% of the samples exceed 43 per 100ml.

TABLE 4-7

Bacterial Levels (mpn per 100ml)

	Fecal Coliform			*Total Coliform*		
Station	*06/25*	*07/27*	*08/29*	*06/25*	*07/27*	*08/29*
N4	93	210	1100	1100	2400	2400
N7	460	460	1100	1100	1100	2400
	240	460	2400	1100	2400	
	93			1100		
B4	460	93	2400	2400	2400	2400
B7	240	460	2400	1100	460	2400
	150	460		2400	460	

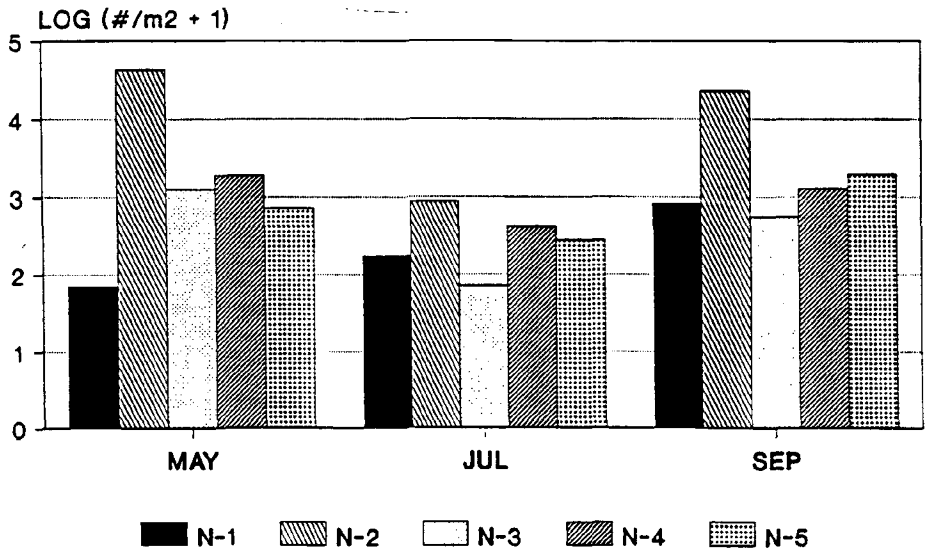
As the data is Table 4-7 clearly show, the freshwater and marine reaches of both streams consistently exceeded the total and fecal coliform standards throughout the study period, regardless of the level of precipitation in the several days prior to sampling. The August samples were taken after an intense early morning thunderstorm struck most of Long Island's south shore and reflect a substantial increase in coliform levels at all stations that afternoon.

4.5 Discussion

A visual comparison of Neguntatogue Creek and Beaverdam Creek is a study in contrasts. Neguntatogue Creek meanders through a heavily developed watershed where vacant land is sparse, the population density is high, and the Creek corridor is frequently littered with debris. A large number of storm drains empty directly into the Creek throughout its entire length. The entire marine reach of the Creek south of Montauk Highway is bulkheaded with the exception of a small natural beach on the eastern bank. Throughout the marine reach, floatable wastes are extremely evident. Neguntatogue Creek is home to a very large number of pleasure boats, principally motorboats. Visually, the natural character of Neguntatgoue Creek has been completely removed by human development.

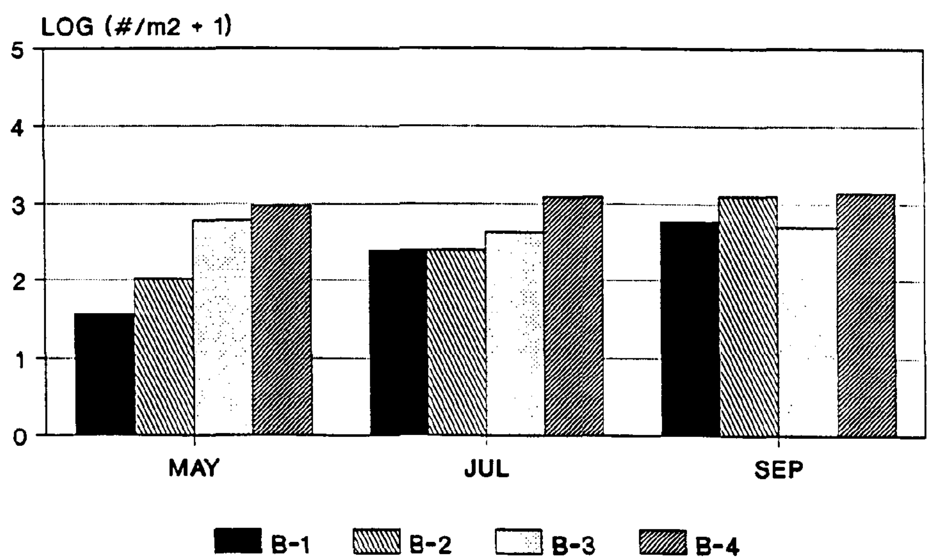
In contrast, throughout its freshwater and, particularly, its marine reaches, Beaverdam Creek has the look and feel of a waterbody in a relatively natural state, only moderately altered by human development and activity. The watershed of Beaverdam Creek is lightly developed, largely for residential purposes. Homes line both banks of the Creek along its freshwater reaches, but do not seem to change the character of the stream. Only a few storm drains empty directly into Beaverdam Creek, at its most seaward end. Natural vegetation lines both banks along much of its freshwater reach. The Creek's marine reach is also extensively vegetated, although primarily with *Phragmites*, indicative of significant disruption along the stream's margins in past years, primarily occasional dredging of the channel in the Creek. Only small patches of native *Spartina* marsh persist near the Creek's mouth and along the eastern bank.

This study has found some evidence of water and environmental quality differences between the two streams that support this visual, aesthetic contrast. But for some important parameters, there was



F: FRESHWATER STATION

Figure 4-20(a)
ABUNDANCE
Neguntatogue Creek (F)



F: FRESHWATER STATION

Figure 4-20(b)
ABUNDANCE
Beaverdam Creek (F)

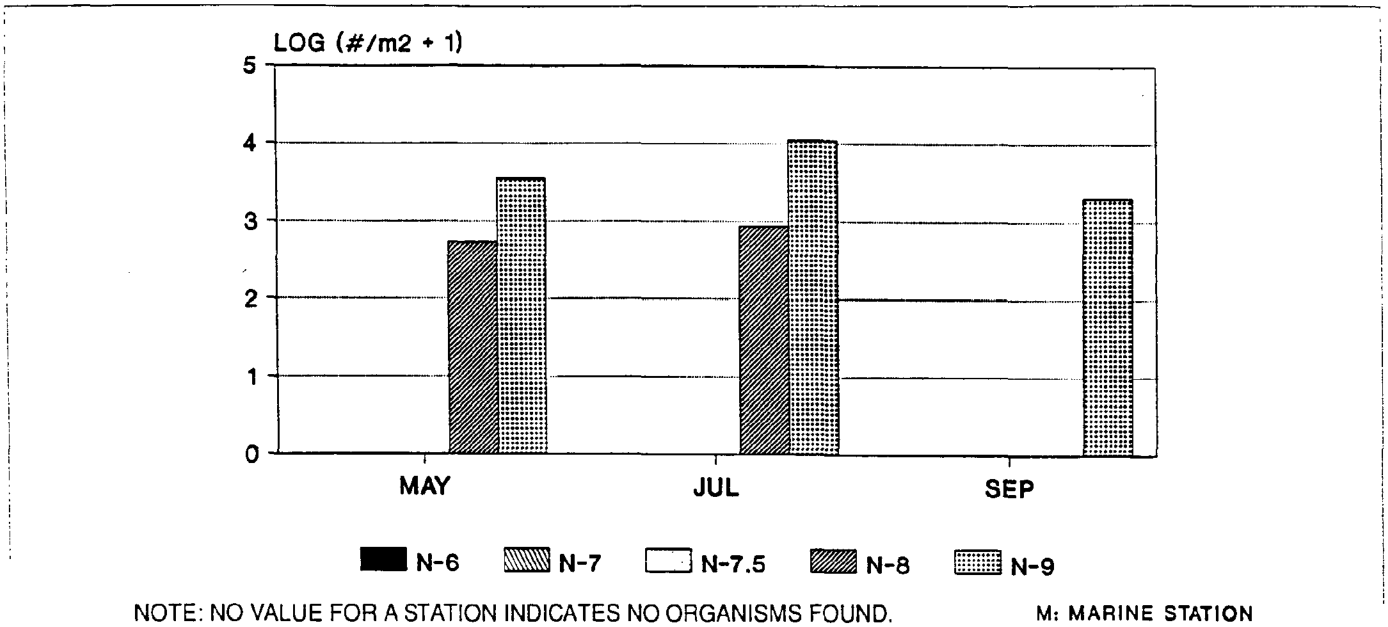


Figure 4-21(a)
ABUNDANCE
Neguntatogue Creek (M)

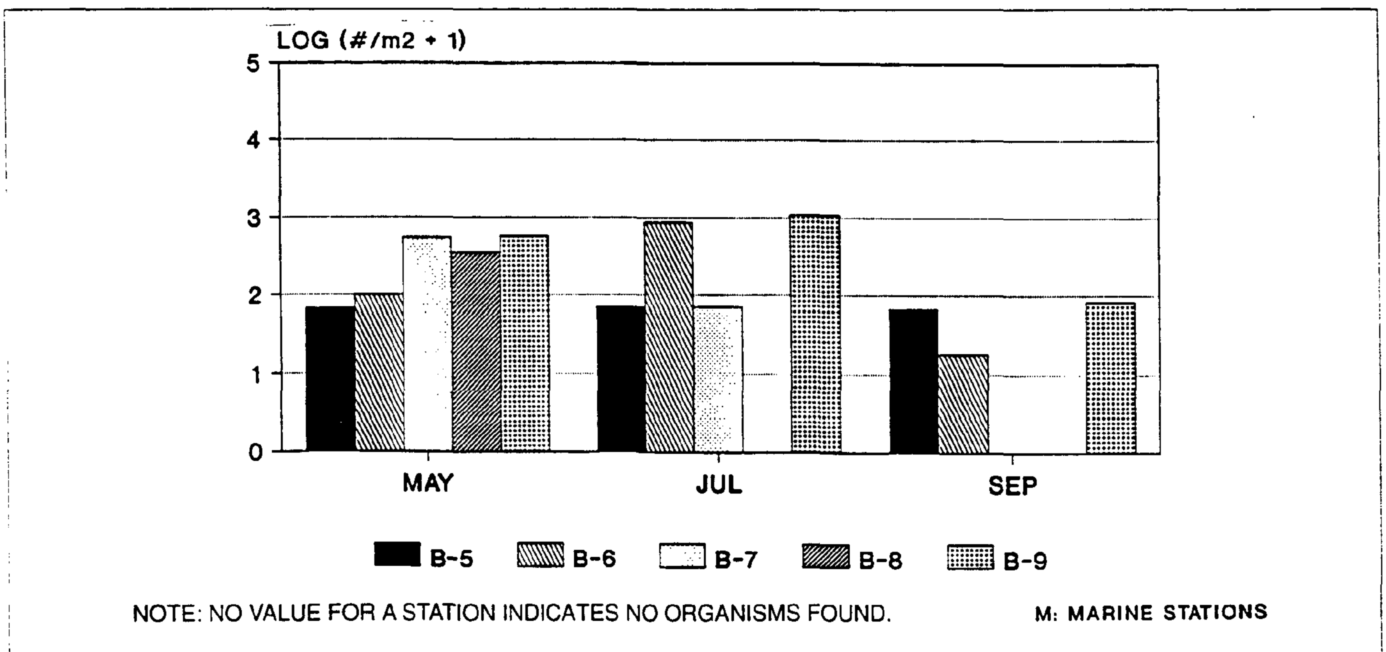


Figure 4-21(b)
ABUNDANCE
Beaverdam Creek (M)

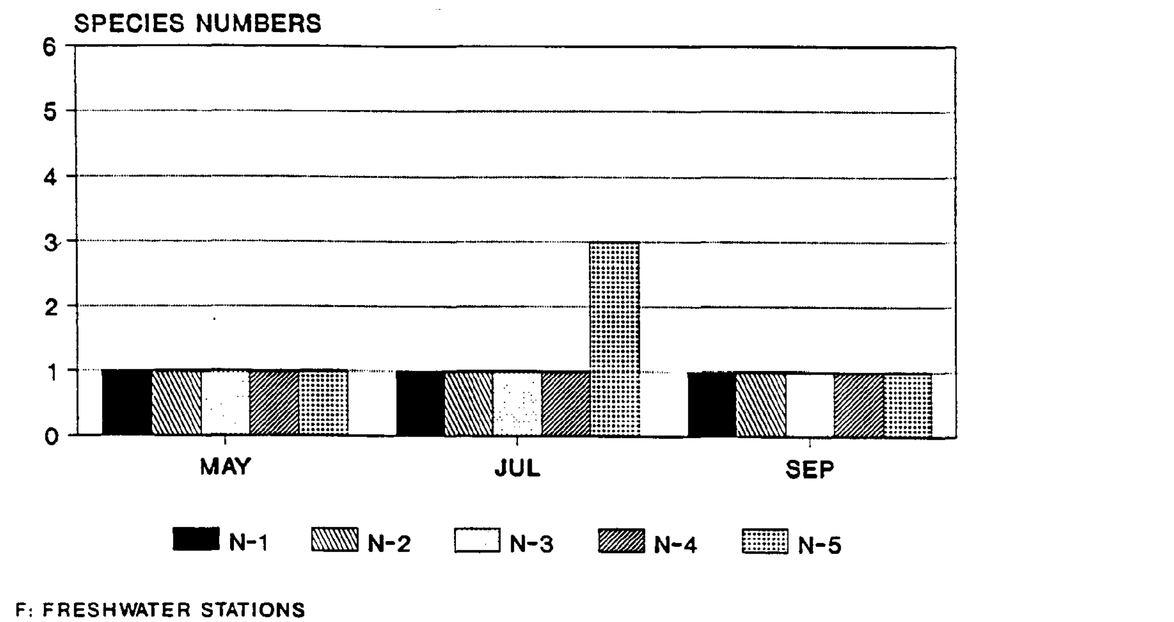


Figure 4-22(a)
SPECIES RICHNESS
Neguntatogue Creek (F)

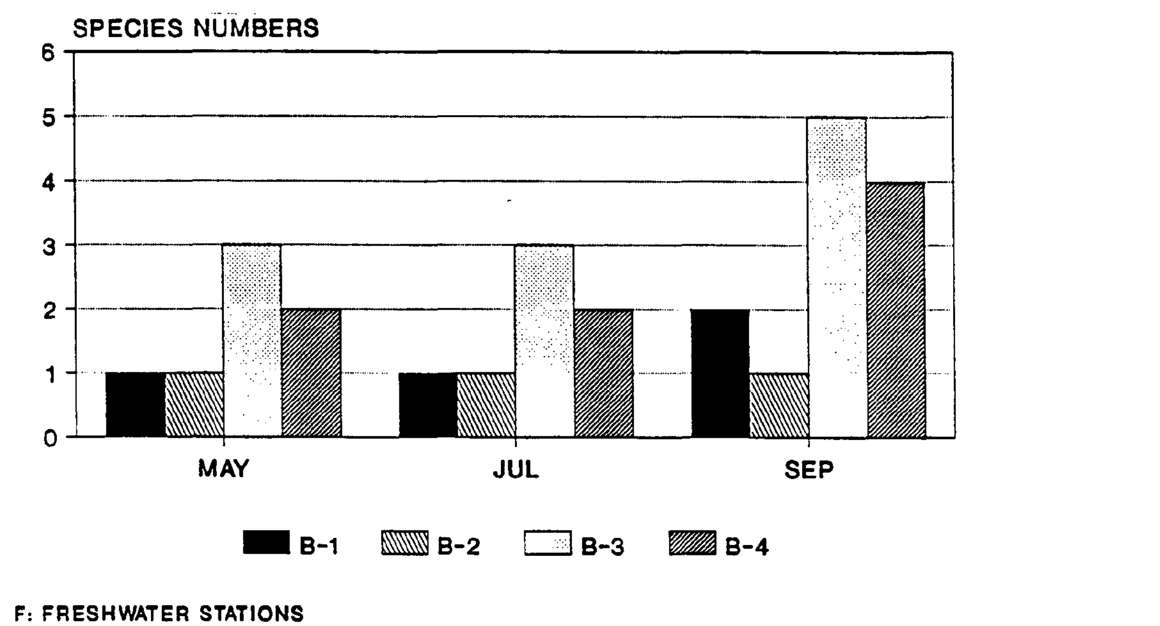


Figure 4-22(b)
SPECIES RICHNESS
Beaverdam Creek (F)

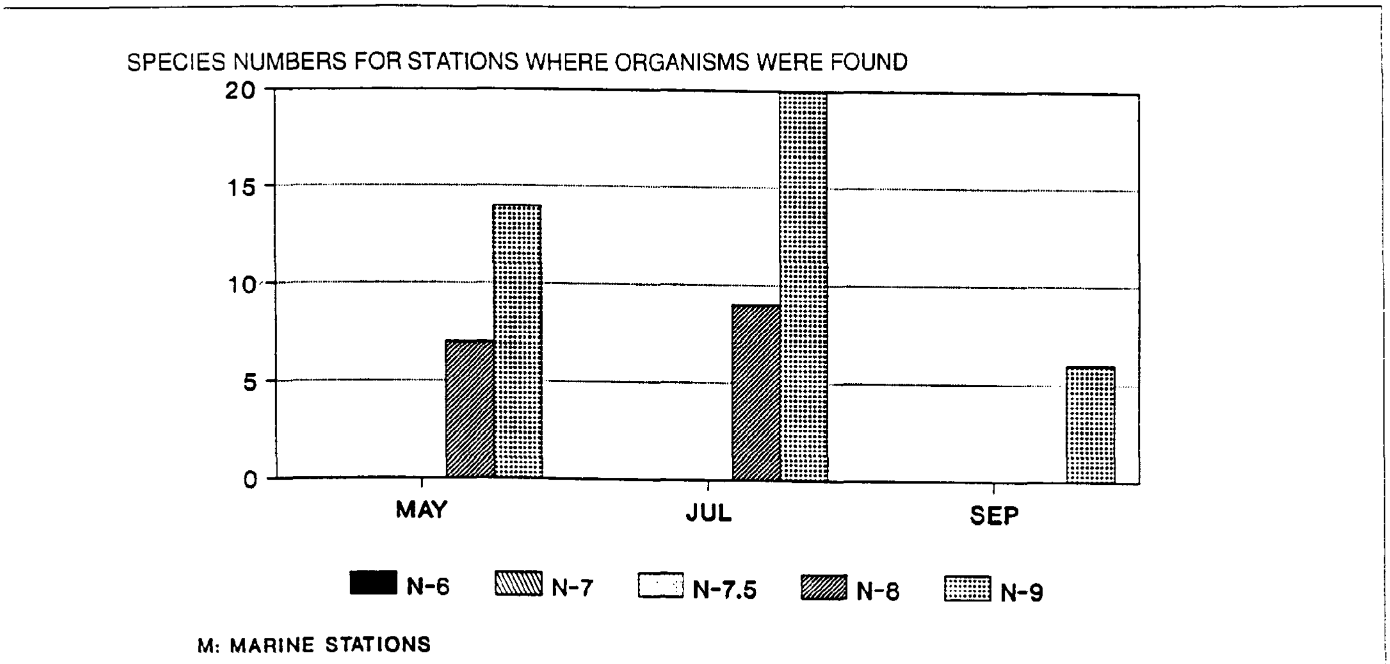


Figure 4-23(a)
SPECIES RICHNESS
Neguntatogue Creek (M)

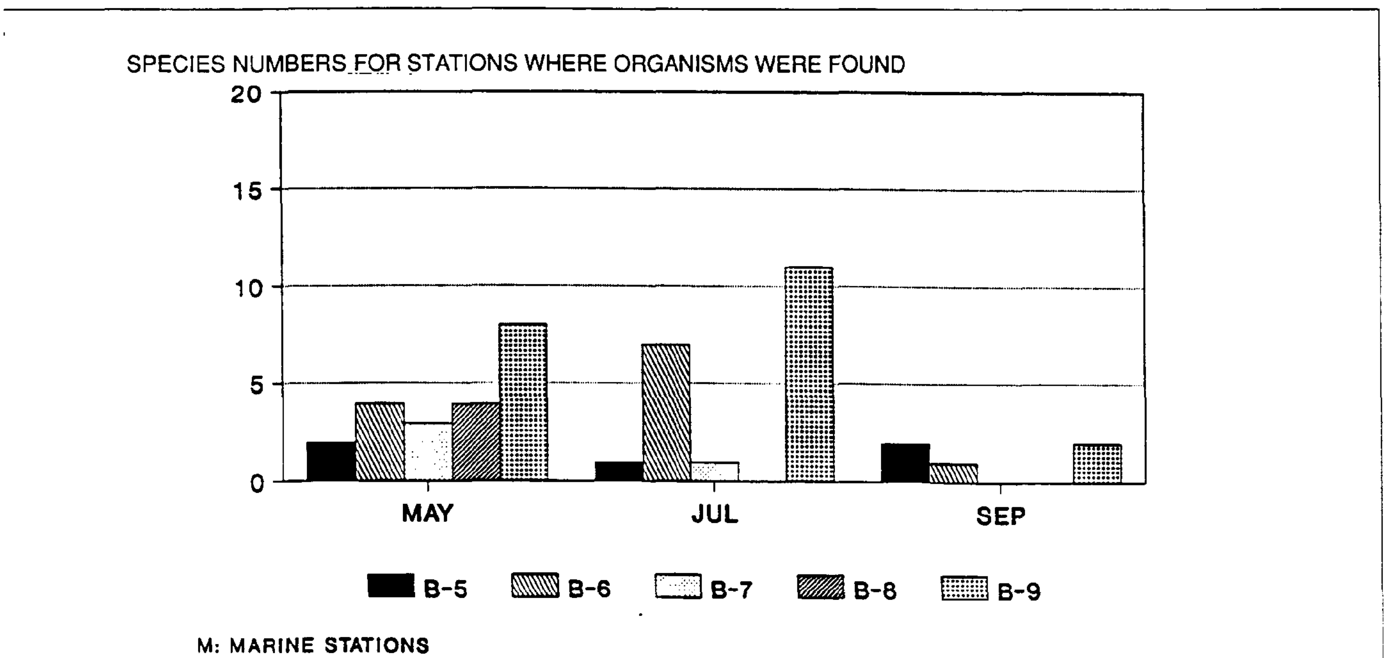


Figure 4-23(b)
SPECIES RICHNESS
Beaverdam Creek (M)

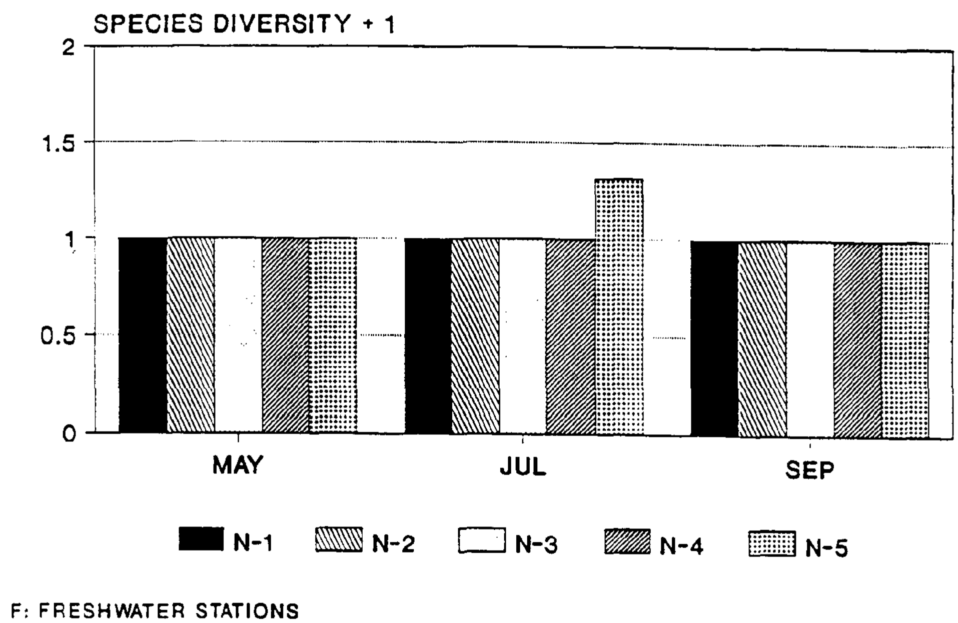


Figure 4-24(a)
SPECIES DIVERSITY
Neguntatogue Creek (F)

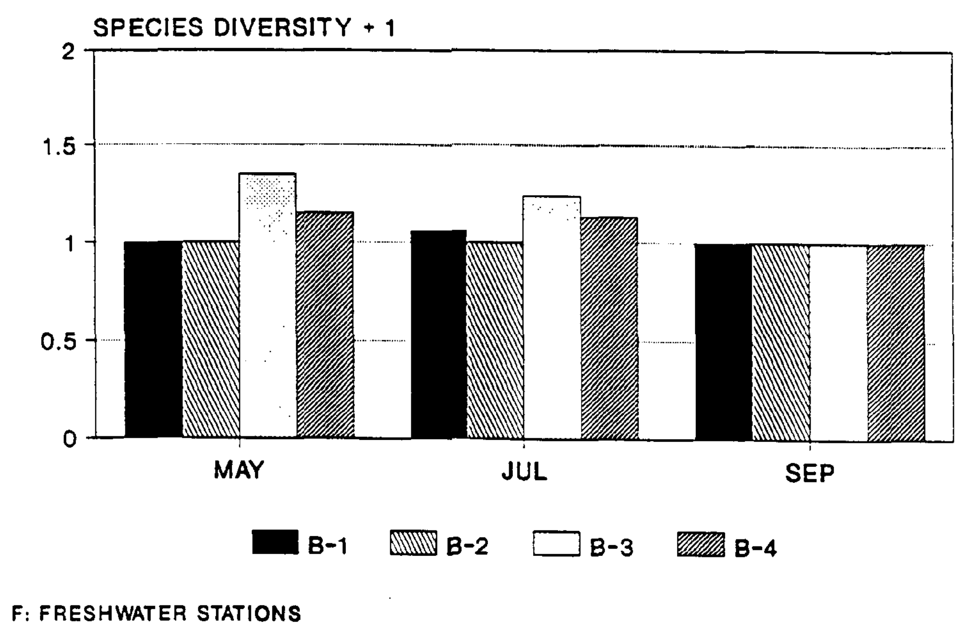


Figure 4-24(b)
SPECIES DIVERSITY
Beaverdam Creek (F)

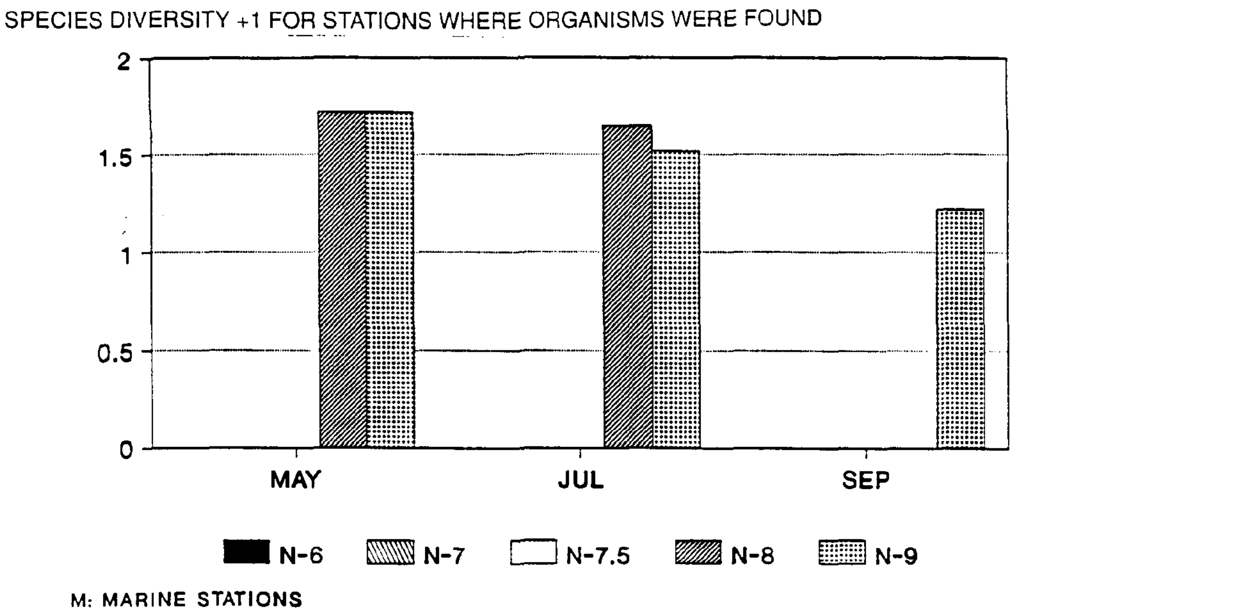


Figure 4-25(a)
SPECIES DIVERSITY
Neguntatogue Creek (M)

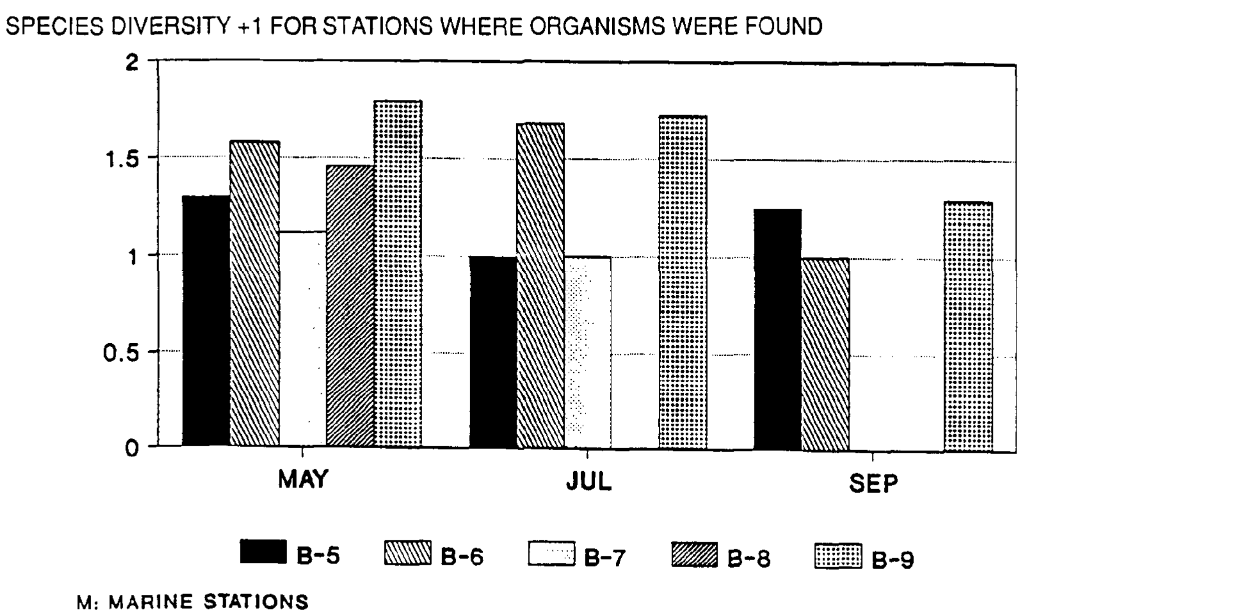


Figure 4-25(b)
SPECIES DIVERSITY
Beaverdam Creek (M)

little persistent, significant difference found between the two streams. For some parameters, this may be partially attributable to an inability to sample frequently enough to detect variations at time scales of less than one month.

This section discusses the environmental quality of the two streams in terms of the parameters examined in this study and, based on the data collected, identifies the major water quality problems in the two streams and the differences between them.

The salinity and temperature profiles of the two streams are quite similar and consistent with profiles developed for other streams in the region. Salinities were higher in Neguntatogue Creek than in Beaverdam Creek, reflecting the higher salinities found in western Great South Bay as compared to eastern portions of the Bay, itself a reflection of the proximity of the western Bay to Fire Island Inlet. While both creeks display vertical and longitudinal gradients in temperature and salinity, those of Beaverdam Creek are sharper and persisted somewhat more throughout the study period. The bottom waters in the marine reaches of both creeks become rapidly hypoxic with the onset of thermal stratification in the spring. Bottom waters in the northern portion of the marine reaches of both streams were essentially anoxic in July and August. Average bottom dissolved oxygen levels were slightly lower in Neguntatogue Creek, although stations B5 (northernmost station in the marine reach) and B8 (at the head of a canal) in Beaverdam Creek had bottom dissolved oxygen levels as depressed as those in Neguntatogue Creek. Supersaturated surface dissolved oxygen levels were encountered in the marine reaches of Beaverdam Creek, associated with intense phytoplankton blooms. This was not observed in the surface waters of Neguntatogue Creek's marine reach, although these waters were, for the most part, well oxygenated throughout the study period.

As in their respective marine reaches, dissolved oxygen levels in the freshwater reach of Neguntatogue Creek were somewhat lower than in Beaverdam Creek, although hypoxic conditions were present during the period of study only at the two most northerly freshwater stations in Neguntatogue Creek. The shallow depths and constant flow in the freshwater portions of the streams combined to keep the water fairly well oxygenated.

Alkalinities in the freshwater reaches of the two creeks appear quite dissimilar. Alkalinity in Neguntatogue appears to be more stable, varying between 60 - 90 mg $CaCO_3$/l and dropping only slightly between the northernmost and southernmost freshwater stations. Alkalinity in Beaverdam Creek, conversely, varies considerably over time and longitudinally. Beginning with the June sampling, alkalinities at the two northernmost freshwater stations in Beaverdam Creek increased from 25-35 mg/l to 85-136 mg/l. Recent (Fall 1989) surveys of Beaverdam Creek surface waters near these two stations found similar high alkalinities (119 mg/l) (Steven Feldman pers. comm.). Unlike Neguntatogue Creek, alkalinity in Beaverdam Creek decreases in a north-south direction, particularly during the June - August period, dropping to 15-35 mg/l at station B4, the southernmost freshwater station.

Streamflow in groundwater-fed surface waters is generally highly variable, depending on the height of the water table and local meteorological conditions. The limited streamflow data for the two creeks collected during this study reflect this variability. The elevated streamflows in Neguntatogue Creek recorded in June have no ready explanation. The nearest weather station to the Creek is at Islip airport, which reported no significant precipitation over the three days prior to the sampling date. It is possible, however, that a localized thunderstorm affected the watershed of Neguntatogue Creek during this period but was not felt at Islip Airport. Review of daily discharge records for gauged streams in the vicinity of Neguntatogue Creek suggest that local rainfall can affect streamflows for a period of up to 5 days after the event.

The streamflow data collected during the course of this study suggest that streamflow in Neguntatogue Creek has not been substantially reduced from that present prior to the sewering of the watershed in 1981. From the limited data presented here, streamflow in Beaverdam Creek appears somewhat more stable over time than that of Neguntatogue Creek, but the time variability of flow within a stream is almost undoubtedly greater than the difference in average flow between the two creeks.

The freshwater and marine waters of Neguntatogue Creek are enriched in the nutrients nitrate, nitrite, and ammonium over those found in Beaverdam Creek. Differences in phosphate levels between the two streams were much less pronounced. The marine waters of Beaverdam Creek had nutrient levels well within the normal range for Long Island coastal waters with the exception of a pulse of phosphate in June in the mid-creek area, possibly reflecting fertilizer runoff from an adjacent farm. The status of the levels of nutrients in the freshwater reaches of Beaverdam Creek is uncertain. Our April sampling revealed low levels, but the June and August samples were lost to contamination. Recent data from an examination of the Creek by the Town of Brookhaven reveal elevated nutrient levels in the upper waters of Beaverdam Creek, perhaps reflecting contamination from the nearby Brookhaven landfill on Horseblock Road (USGS unpublished data).

Primary production as measured by chlorophyll a differed between the two streams. Neguntatogue Creek freshwater stations revealed slightly higher chlorophyll levels than the freshwater stations of Beaverdam Creek. But chlorophyll levels in the marine waters of Neguntatogue Creek were generally lower than those of Beaverdam Creek, the greater nutrient levels in Neguntatogue Creek notwithstanding. This may reflect some other inhibiting factor governing phytoplankton production in Neguntatogue Creek. As mentioned earlier, the marine reaches of Beaverdam Creek are subject to periodic algal blooms.

There were no clear, persistent differences in the phytoplankton assemblages of the two streams in terms of total abundances or species composition. The short and episodic nature of phytoplankton blooms relative to the sampling interval constrain the ability to distinguish between the flora of the two streams. The species observed at the various stations are common members of the phytoplankton and suggest no unusual shifts in community structure were occurring. The high abundance of *Minutocellus* in June at Station N9 was remarkable, but the spatial and temporal extent of this event cannot be determined from the samples.

The marine sediments of Neguntatogue Creek contain greatly elevated levels of several heavy metals. In particular, lead and copper are found at levels that are among the highest recorded in the Long Island area. Sediment metals in Beaverdam Creek are much lower, although still above the pre-industrial basal levels believed typcial of Great South Bay sediments. The presence of these high metals levels in the sediments of Neguntatogue, and the lower levels found in the several pockets of fine-grained sediment in the Great South Bay proper, suggest that Neguntatogue Creek, and perhaps many of the other creeks entering the Great South Bay, are sinks for heavy metals and do not serve as important conduits whereby metals contained in stormwater runoff eventually reach the open waters of the Bay.

The benthic invertebrate community of the two creeks is characterized by the dominance of oligochaete worms in the freshwater reaches and a depauperate community or complete absence at times of organisms in much of the marine reaches. The benthic communities at the two open Bay stations south of each Creek are representative of those found in nearby coastal and estuarine waters. For example, O'Connor (1972) observed mean benthic macrofaunal abundances in Moriches Bay of 5,402 animals/m^2, while a later study in the same area found a mean benthic abundance of 4,445 animals/m^2 (Cerrato 1986). The mean abundance of benthic organisms, including all stations from both creeks and open bay stations, was 3,082 animals/m^2. Benthic abundances are less in stressed environments. The benthic abundances observed in this study, particularly at the marine stations in each creek, approximate those observed in seriously degraded coastal waters. For example,Cerrato and Bokuniewicz (1985) observed a mean benthic abundance in Raritan Bay of 795 animals/m^2, in Flushing Bay of 590 animals/m^2, and in Bowery Bay of only 127 animals/m^2. Lowered benthic abundances can be reflective of either pollutant related water quality degradation, the naturally variable environment of shallow tidal creeks, or frequently, a combination of both. The pattern of higher abundances in freshwater portions of a creek that fall to very low levels in the marine portions before rising again in open estuarine waters is one that is commonly encountered (R. Cerrato pers. comm.).

The higher abundances of the oligochaete worm *Tubificidae spp.* at the freshwater stations in Neguntatogue Creek suggest that these stations are more organically enriched than those of Beaverdam Creek. Tubifex worms are generally indicative of polluted environments. Moreover, benthic species richness and diversity were lower in Neguntatogue Creek than in Beaverdam Creek, again indicating that Neguntatogue is the more stressed environment.

Two notable features of the benthic community structure in the streams are the steady decrease in the abundances of benthic organisms in the southerly direction in Beaverdam Creek and the complete absence of benthic organisms from several of the marine stations in Neguntatogue Creek from May to September. These data on benthic macrofauna in the two Creeks indicate that Neguntatogue is the more stressed environment.

The waters of the freshwater and marine reaches of both creeks persistently contravene New York State standards for total and fecal coliform bacteria. Most of the coliform bateria present in stormwater runoff are naturally occuring bacteria washed from soil particles. Most of the fecal bacteria in runoff, however, are contributed by various warm-blooded animals. On Long Island, these are primarily cats, dogs,opossums, and birds.

Major sources of bacterial contamination to Neguntatogue Creek appear to be stormwater runoff and resident bird populations. Prior to sewering of the surrounding area in 1981, leakage from residential septic tanks had a significant impact on groundwater and surface water quality in the watershed of Neguntatogue Creek (Suffolk County Executive Office: Special Projects 1980). Such leakage may remain an important source of excess nutrients, because significant numbers of residences and commercial or industrial establishments have not hooked up to the sewer system. Feller's Pond at Fireman's Memorial Park supports a variable waterfowl population averaging 75-100 birds (primarily ducks, geese, and seagulls) at a particular time. Studies conducted as part of the Nationwide Urban Runoff Program (NURP) (LIRPB 1982) demonstrated that local waterfowl poulations could add significantly to total and fecal coliform levels present in runoff and receiving waters.

Little direct stormwater runoff reaches Beaverdam Creek, except at its most southerly end. The elevated bacterial levels found in Beaverdam Creek are probably due to the area's waterfowl and small mammal populations and to the contamination of local groundwater by residential septic systems.

The limited ambient water bioassay tests conducted in the course of this project suggest that the freshwater and marine reaches of Neguntatogue Creek and Beaverdam Creek are, at times,toxic to finfish, although the specific agent(s) and/or condition(s) creating this toxicity are unknown. This toxicity apparently declines in Neguntatgoue Creek from April to August. Acute toxicity of Beaverdam Creek water to finfish appears to be somewhat less than that of Neguntatogue. Toxicity of the waters of both Creeks to invertebrate test organisms is low.

On balance, the water quality and general environmental quality of Neguntatogue Creek is lower than that of Beaverdam Creek. For some of the parameters assessed in this study, this difference is striking (eg. sediment metal contamination). For other parameters, the differences are much less. Additionally, for some of the parameters sampled, it is impossible to determine how removed each creek is from a natural, pre-industrial level of that characteristic. This is the case, for example, with dissolved oxygen and coliform bacteria, two parameters whose profiles reflect poor water quality conditions in both creeks. The marine bottom waters of both Neguntatogue and Beaverdam Creeks annually suffer a certain level of oxygen loss through mineralization and decomposition of naturally-occurring organic material. Data on bottom oxygen levels from truly pristine creek environments on Long Island are not available to estimate the degree of this natural hypoxia.

Similarly, there is no information on naturally occurring coliform bacterial levels in poorly-flushed tidal creeks on Long Island. It is possible that the total or fecal coliform standard would be approached or even exceeded in these environments under entirely natural conditions.

While Neguntatogue Creek may be degraded in a number of ways relative to Beaverdam Creek, this does not suggest that these and the other creeks entering the Great South Bay necessarily export all of their water quality problems to the Bay proper. While such transport does take place for many of the dissolved consitutents, the bottom sediments of these creeks appear to be effective traps for sediment-bound metals (and perhaps sediment associated organic pollutants) as well as organic material, which enters the marine reaches of these streams through streamflow from the freshwater reaches and bottom influx of Bay water.

Chapter Five

BMPs for Control of Nonpoint Source Pollution

5.0 Introduction

The term BMP, or *Best Management Practice*, has gained wide acceptance as a general term designating any method for controlling the quantity and quality of stormwater runoff. A best management practice (BMP) is considered to be either:

- a practice (routine procedure) that reduces the pollutants available for transport by the normal rainfall-runoff process or
- a device that reduces the amount of pollutants in the runoff before it is discharged to a surface water body

It is almost impossible technically and economically to completely eliminate NPS pollutant discharges to a receiving water body. Realistic objectives of an urban NPS management program are either:

- to sufficiently reduce pollutant levels to eliminate or mitigate an existing water quality problem or
- to avoid the creation of a future problem where none exists now

This chapter presents an overview of the different types of BMPs that may be considered in the development of urban NPS management plans. Institutional aspects of the development of an effective urban NPS management program are not emphasized here, but planning activities must include a recognition of the need to develop an understanding of the issues at several levels of local government, and provide support for the resolution of institutional issues. This may involve the identification of the relationships between NPS management plan features and existing programs, plans and activities of New York State, Suffolk County, town and village officials, planners and public works personnel, whose responsibilities will provide the institutional framework for implementation of many of the important elements of a NPS management plan.

5.1 Types of Urban BMPs

Control techniques that have proved effective for the control of nonpoint runoff pollutant discharges from urban areas are identified below. These techniques include both structural and non-structural techniques, and can be grouped into the following four categories, based on the operating principle or the physical mechanism that reduces the amount of runoff pollutants discharged to surface waters. There is no generic method by which these different control techniques can be ranked either qualitatively or quantitatively. Site-specific conditions usually determine which practices are best, or even whether a particular approach is appropriate to consider.

....*STRUCTURAL*

- DETENTION BASINS - The term *detention* is applied where the runoff is temporarily stored, and apart from relatively minor incidental losses due to evaporation or percolation, it is subsequently discharged to a surface water. Control results from a reduction in pollutant concentrations due to settling during the period the runoff is detained.
- RETENTION DEVICES - The term *retention* is applied when a practice results in the permanent capture of all or part of the runoff, so that it never discharges directly to a surface water. The usual mechanism by which stormwater controls permanently *capture* surface runoff is by infiltration. These techniques are often referred to as infiltration BMPs.

....*NON-STRUCTURAL*

- VEGETATIVE CONTROLS - Vegetative controls include techniques that provide for controlled contact between stormwater runoff and vegetated areas. Pollutant removal occurs by a combination of processes such as filtration, sedimentation and biological uptake that reduce pollutant concentrations, and/or by a reduction in runoff volume due to infiltration or evapo-transpiration.
- SOURCE CONTROLS - Source control techniques include any practice that either:
  - reduces the amounts of accumulated pollutants on the land surface available for washoff by rainfall or
  - regulates the amount of impervious area to reduce the portion of rainfall that will appear as runoff or
  - excludes inappropriate discharges to storm drains

5.1.1 Detention Basins

The dominant treatment mechanism is the reduction of pollutant concentrations by sedimentation, so that this practice is most effective for suspended solids and the fraction of a pollutant associated with particulate matter. For example, most of the lead that is present in urban stormwater is present in particulate form. The soluble fraction of total lead is typically on the order of only about 10 percent, and as a result the removal efficiency for lead is comparable to that for sediment. In contrast, as much as 40 or 50 percent of a pollutant such as copper in runoff may be present in a dissolved form, and not susceptible to removal by sedimentation.

Although the main benefit results from the reduction of pollutant concentrations in the runoff, water quality impacts may also be reduced by the delayed release of stormwater runoff volumes. The resulting reduction in peak discharge flows will tend to reduce stream bank erosion and place less stress on the physical habitat. A slower release of stormwater to a flowing stream will produce lower concentrations of runoff pollutants in the stream after dilution.

Depending on the design of the inlet and outlet structures, detention basins can be classified into the following three catgories.

- DRY PONDS - These are basins with the outlet located at the bottom. They are almost always dry, except infrequently and for relatively short periods following larger storm events. The outlet size is restricted to limit the maximum flow rate. Dry ponds are used for flood and erosion control and are not effective for water quality control purposes. They may often be practical to retrofit for purposes of water quality control.
- WET PONDS - These basins employ outlet structures designed to maintain a permanent pool of water. They can provide high removal efficiencies for particulates, and have also been observed to be effective in significantly reducing soluble nitrogen and phosphorus concentrations by means of biological activity such as algal growth in the pool of water.
- EXTENDED DETENTION DRY PONDS - These basins employ an outlet structure that will cause most storms to pond in the basin. Following a storm these basins drain in about 24 to 48 hours and will be dry at all other times. The outlet structures may be either perforated risers or subsurface drains. They provide a practical technique for retrofitting dry ponds to obtain water quality benefits, and can provide particulate (and the associated pollutant) removal efficiency equivalent to that for wet ponds.

Pollutant removal efficiency of an otherwise properly designed and maintained detention basin may be influenced by seasonal factors such as algal growth, shoreline vegetation, and ice formation. However, overall efficiency is determined principally by the size of the basin (the available storage volume provided) relative to the amount of runoff it receives during storm events. For any storm event, the volume of runoff will depend primarily on the size of the contributing drainage area, and the proportion of impervious area. The latter is influenced by land use. Since performance of a basin will vary with storm size, pollutant removal estimates reflect the long-term average removal efficiency over all storms.

A variety of basin sizing rules are in current use, depending on the experience and/or preference of the jurisdiction. In some of the agencies that have been active in the implementation of urban stormwater controls for a number of years, the sizing rules have changed over time, or alternate rules have been adopted for different situations. There is no generally accepted rule or standard for the size of a detention basin. Four commonly used basin sizing rules are discussed below.

- DESIGN STORM BASIS - Basin volume is set equal to the runoff produced by a specified design storm. For example, the 1 year or the 2 year, 24 hour duration storm event is sometimes used to specify the size of an extended detention basins where a reduction of flooding and peak flow are important. The volume of rainfall must be converted to the amount of runoff it will produce, and this will vary with the land use distribution (percent impervious area) of the watershed.
- FIRST FLUSH BASIS - Basin volume is designed to store 1/2 inch of runoff per impervious acre of the contributing watershed. This is the most common rule, but the same rule, using 1 inch, is sometimes used. This rule is attractive, because it is simple to use and apply.
- MEAN STORM VOLUME BASIS - Basin volume is specified as a multiple of the mean runoff volume of all storms. The value of mean runoff is determined by a statistical analysis of the rainfall records. This method has the advantages of being able to base the size on the desired level of performance, and to account for regional rainfall characteristics. For example, the storm that produces 1/2 inch of runoff per impervious acre is a more frequent event in the southeast portion of the US. than it is in the midwest, and there would be corresponding differences in the long-term pollutant removal efficiencies for otherwise similarly sized basins in the two regions. For some areas, this approach has been used (with local rainfall characteristics) to determine the storage volume required to produce a particular performance level, e.g., 70% TSS (*Total Suspended Solids*) reduction, and then translated to a simple-to-apply sizing rule for everyday use.
- RESIDENCE TIME BASIS - Basin volume is designed to provide a specified residence time. Where this is used, long residence times (typically 14 days) are used. This rule generally results in larger basins that provide higher levels of reduction of most pollutants. However the principal objective is to enhance the removal of soluble nutrients by improving conditions favorable for growth of algae and aquatic plants.

A comparative evaluation of the above four approaches to determine basin size can be obtained by the approximate ratio of the basin *volume* (VB) and the *mean runoff volume* (VR). This requires an appropriate analysis of the rainfall record and the characteristics of the contributing drainage area. For this region of the country, the rainfall volume for the mean storm event is approximately 0.6 inches. This can be taken as an approximation of the runoff volume if we consider only the impervious acres. On this basis, a basin with a VB/VR ratio of 1.0 would provide approximately 2200 cubic feet of storage per impervious acre in the watershed. Note that the design volume of a basin is directly proportional to the value of VB/VR. Approximate values of VB/VR for different basin sizing rules are presented in Table 5-1.

Depending on the size selected, wet ponds and extended detention ponds can reduce suspended solid concentrations in stormwater runoff by 50 to 95 percent. Removal efficiency for other pollutants is generally proportional to the pollutant fraction associated with (adsorbed on to) the particulates. For screening level analysis, approximate removal ranges that can be expected for detention basins are shown in Table 5-2. The performance levels shown are estimates of the approximate order of the removal efficiency for different pollutant types and basin sizes. Note in general that the larger the basin volume, the greater the removal efficiency. However for VB/VR ratios larger than 2.5 or 3, increases in the basin size result in diminishing improvements in the performance efficiency.

Note also that there is very limited data available on the removal of bacteria. The high removal efficiencies shown for bacteria in Table 5-2 may be deceptive, because the water quality criteria levels are very low relative to the concentrations usually present in stormwater.

....ADVANTAGES:

- Detention basins are effective runoff control devices, and there is an appreciable body of experience that attests to their performance capabilities, and provides a source of guidance for many important design details.

TABLE 5-1

Ratio of Basin Volume to the Mean Runoff Volume for Different Design Rules

Rule	Characteristic value	*Volume Ratio (vb/vr)*
First flush	½ inch per impervious arce	1 to 2
Mean storm volume	1 inch per impervious arce	2 to 4
Residence time	14 day residence time	4 to 5
Design storm	1 year storm	7 to 8
Design storm	2 year storm	8 to 9

TABLE 5-2

Typical Percent Pollutant Removed for Different Ratios of Basin Volume to Mean Runoff Volume

Pollutant	Percent Removal For Indicated vb/vr			
	1	2.5	5	*7.5*
Suspended	50-60	70-80	85-90	90-95
Organics (BOD, COD)	25-30	35-40	40-45	45-50
Total N and total P	30-40	40-50	50-60	60-70
Lead	45-50	60-70	70-80	80-90
Other heavy metals	30-35	40-45	40-50	45-60
Bacteria	about 90 percent to about 99 percent			

- They are suitable for relatively large drainage areas, and can be readily incorporated into the overall plans for new developments. Properly designed detention basins can enhance the value of the surrounding property.
- Existing dry ponds, previously installed for flow control, can often be economically converted to serve as extended detention basins and provide water quality control.

....*LIMITATIONS:*

- It is important to note that detention basins can become eyesores if routine maintenance is not performed.
- Removal of accumulated sediments will be required after 10 to 20 years of service, and can be quite expensive.
- The availability of sufficient land area at an appropriate location in the watershed can be a problem.
- Finally, it is usually difficult and often impossible to construct detention ponds in an existing built-up area.

5.1.2 Retention Devices

Retention or infiltration devices enable a fraction of the runoff volume to percolate into the ground, and hence reduce the discharge to a surface water body. Consequently, the removal efficiency is the same for all pollutants, and is proportional to the percentage of the total runoff volume that infiltrates. Many of the pollutants in urban runoff are effectively trapped in the upper soil layers, and do not reach the subsurface aquifer. This filtration or adsorption mechanism is particularly effective in the case of suspended solids, bacteria, heavy metals and phosphorus. Note that some of the percolating runoff may reach the surface water body, usually after a considerable delay, and after being *treated* by contact with the soil. Retention devices can be classified into the following three catgories.

- INFILTRATION BASINS - These are relatively large open depressions, produced by either natural site topography or by excavation, in which runoff is temporarily stored while percolation occurs through the bottom or the sides. Outlet devices to allow overflow of excess inflows are generally provided but are elevated so to maximize the storage volume. Infiltration basins are normally designed so that any stored runoff will percolate in no more than a day or two. Thus such basins are generally dry.
- INFILTRATION TRENCHES AND DRY WELLS - The design of infiltration trenches and dry wells is similar. The major difference is in the size and the configuration. These are essentially excavated holes filled with coarse aggregate and then covered. Dry wells are used primarily for roof drainage from residential and commercial sites. Trenches or modifications of trenches serve larger drainage areas, and are particularly applicable for streets and parking lots in commercial areas.
- POROUS PAVEMENT - The main practical application is for parking lots. Heavy traffic and heavy loads that would tend to occur in most streets would compact the surface and reduce the infiltration rate in time. Also, the vacuum sweeping to remove fine sediments from the pavement, which is an important recommended maintenance procedure, is most realistic for parking lot areas.

Key design factors that determine performance are the hydraulic conductivity of the underlying soil and the size of the device relative to the contributing drainage area. In this case, the size refers to the surface area available for percolation, and to the storage volume. Examples of typical sizing rules that have been applied include the following:

- Storage volume for 1/2 inch of runoff per impervious acre, or storage volume for 1 inch of runoff from the entire watershed. These rules are usually applied for infiltration trenches. Generally, trenches are made relatively wide and shallow, and percolation rates range from 0.5 to 1 inches per hour.
- Storage volume equal to the volume of runoff from a 2 year storm. This sizing rule is usually limited to infiltration basins, and makes assumptions comparable to the preceeding rule.
- Percolating area and storage volume may be determined by analyzing the rainfall records and soil percolation rates for the site or area.

Depending on the size and the soil characteristics, infiltration devices are capable of achieving removal efficiencies up to 99 percent. The removal of pollutants for different sizes and designs in the Maryland-Northern Virginia area are listed in Table 5-3. Performance can be expected to differ for areas with different rainfall and soil types, but the indicated efficiencies are typical of the water quality performance that could be produced by infiltration BMPs, in otherwise suitable areas on Long Island.

TABLE 5-3

Typical Percent Pollutant Removal for Rentention Devices

Pollutant	*Percent Removal for Indicated Size* *½ inch per impervious acre*	*1 inch from total area*	*2 yr. runoff vol*
Suspended solids	75	90	99
Organics (BOD, COD)	70	80	90
Total N and total P	45-55	55-70	60-75
Heavy metals	75-80	85-90	95-99
Bacteria	75	90	98

For retention basins, *treatment rate* can be thought of as the product of the percolation rate and the available percolating area. The performance improves as the treatment rate is increased, either because of higher soil percolation rates or larger percolation surface areas. Efficiency can be enhanced by the amount of storage volume provided. However, large excess storage volumes that do not have time to drain between storms are not only wasteful of resources, but may be detrimental to basin performance by preventing the rejuvenation that occurs during dry periods.

....ADVANTAGES:

- Infiltration devices are capable of very high pollutant removals.
- In many cases they can be built in developed areas.
- In addition to water quality control, they also reduce stormwater runoff to surface water bodies during and after storm events and provide desirable subsurface recharge resulting in an increase in low, dry-weather stream flows. This has the desirable effect of reducing flow variations in streams.

....LIMITATIONS:

- A variety of site specific factors (impermeable soils, high water table, bedrock, etc) restricts the applicability of this type of BMP.
- Care during installation is necessary to prevent compaction of soil by construction machinery, or the sealing of infiltration surfaces by sediment generated during construction activities.
- Even during normal operating conditions, infiltration devices require pretreatment (e.g., grass filter strips, geo-textile cloth) to reduce the amount of coarse sediment reaching the infiltration surface.

5.1.3 Vegetative Controls

Vegetative BMPs include a variety of landscaping arrangements that serve to increase the contact of rainfall and stormwater runoff with appropriate types of vegetation. Vegetative control practices have the ability to reduce pollutant discharges by reducing the quantity of runoff through enhanced infiltration, and to reduce concentrations through a combination of filtration, sedimentation and biological uptake. The major types of vegetative BMPs include the following.

- BASIN LANDSCAPING - Basin landscaping can be addressed during early development of a watershed and can have a significant effect on the control of NPS pollutants. The objectives of basin landscaping include but are not limited to minimization of impervious surface area; protection and utilization of existing wetlands; provision for green-belt buffers along stream banks; routing of runoff flow through vegetated areas and away from erosion-prone steep slopes. Careful selection of vegetation most suitable for site conditions has an important bearing on physical appearance and the long-term performance of basin landscaping.
- WETLANDS - As part of site landscaping, it is possible to create new shallow marsh wetlands specifically designed to operate as an urban runoff control measure. In rare cases, there may be an existing wetland of appropriate type, size and location, to warrant its consideration as a BMP for urban runoff. However, in such cases, issues that will be difficult to resolve with current knowledge, such as the potential of urban runoff flows or pollutants to damage the existing wetland ecosystem, need to be addressed.
- GRASSED SWALES - Grassed swales are a shallow grass covered channel, rather than a buried storm drain, that is used to convey stormwater. Grass channels are mostly applicable in residential areas. They require shallow slopes, and soils that drain well. Often grassed swales are used to provide *pretreatment* of runoff to other controls, particularly infiltration devices.
- FILTER STRIPS - These are similar in concept to grass swales, but are designed to distribute runoff across the entire width and result in an overland sheet flow. These strips should have relatively low slopes, adequate length, and should be planted with erosion resistant plant species. They are often used as pretreatment for other BMPs, for example, by being placed in the flow path between a parking lot and an infiltration trench.

Performance of vegetative controls is strongly influenced by the depth and velocity of flow through or across the device (determined by slope and flow distribution), and by contact time (determined by the length of the flow path). The use of small check dams to produce temporary ponding of runoff improves performance by enhancing the infiltration rates. Care in selecting plant species appropriate for site specific conditions, and routine maintenance to maintain optimum height are important maintenance requirements.

The pollutant reduction capabilities of vegetative controls are not documented as well for the other types of BMPs. Available information suggests that under favorable conditions, vegetative controls can achieve moderate removals of particulates such as sediment and heavy metals. They are generally not effective in reducing nutrients.

Many of the important design features are determined by physical characteristics of the site, over which the planner or designer has little or no control. Thus, both the applicability and the degree of performance that can be expected are highly site-specific.

....ADVANTAGES:

- The costs for vegetative controls tend to be lower than those for detention and infiltration practices.
- With appropriate planning and design, they can enhance the visual attractiveness of a site.
- Vegetative controls are usually most appropriate to provide pretreatment of runoff in order to improve the operation and maintenance of other BMPs.

....LIMITATIONS:

- Vegetative controls are usually not adequate to serve as the only runoff control practice for a site.
- The overall pollutant reduction that can be obtained from vegetative practices is usually limited, and depends to a substantial degree on the physical characteristics of individual sites.
- Seasonal differences in performance can be important. Removal effectiveness for some pollutants can be markedly different during growing and dormant periods.
- Information on removal efficiencies for the range of conditions that might be encountered is relatively limited.

5.1.4 Source Controls

This category of BMPs includes any practice that (a) reduces the amounts of accumulated pollutants on the land surface available for washoff by rainfall, or (b) regulates the amount of impervious area to reduce the amount of runoff, or (c) excludes inappropriate discharges from storm drains. The basic nature of the practices that can be included in the source control category, and in the elements involved in their implementation, cover such a broad range that there is no single best way to organize and classify them.

Source controls may be considered in terms of specific practices that address one or more of the above objectives. Depending on the basic nature of a practice, it may be associated with specific parcels or localized sites, or alternatively it may relate to application over broad areas. In most cases, a management plan will incorporate an array of different source controls that are applicable for the area. All source control BMPs involve each of the following *implementation* aspects, to a greater or lesser degree.

- EDUCATION - Since many source control practices require either active public participation, or general public acceptance, public education elements are an important feature. Developing a public understanding of the need for an action, the benefit it can produce, and the pertinent details of its implementation, will be critical to success, and will require a specific program element that addresses this requirement.
- REGULATION - In many cases appropriate legal authority will have to be developed and assigned to an appropriate agency. Where this may deviate from the historical role, education and persuasion will be important. There may be a need for redefining roles or establishing new agencies or departments. For example, an appropriate regulation against a particular form of pollutant discharge and legal enforcement authority may exist. If however, the enforcement authority resides in a police department, the situation may fall so far down on the priorities dictated by the general mission of a police agency, as to preclude any realistic expectation of active enforcement. This is an example of one of the variety of issues that will have to be resolved, that may not be apparent in a simple listing of the elements of a particular NPS control action.
- GUIDANCE - For some source controls, specific formal technical guidance may have to be developed and distributed to assure effective implementation. Examples include details of erosion control practices, oil separators that may be required for service stations, or detention facilities for new residential developments.

There is no consistent way to characterize the salient design features of the variety of different types of practices that can be included in the source control BMP category. An important factor is the *application density*. This generally (depending on the nature of the particular practice) addresses how actively, frequently and/or thoroughly the practice is pursued, and over how much of the total urban area it is applied. For example, the frequency at which each catch basin is cleaned; the number of streets or parking areas that are swept and how often the sweeper returns to a particular location; are examples of application density, and ultimately of how effective a source control practice will be in reducing NPS pollutant loads from an overall urban area.

Some specific source control BMPs that have broad general applicability are identified below, with examples of some of the more important elements of the general practice that are necessary for effective implementation. The list is not exhaustive; local situations can be expected to suggest other practices that are not included in this discussion. In addition, some of those that have been included in the list may not be applicable in all areas.

Exclude Inappropriate Discharges to Storm Drains

ELIMINATE ILLICIT CONNECTIONS - This is one of the more important categories. The NPS stormwater permit regulations emphasize the detection and elimination of non-stormwater discharges to storm drainage systems. Elements of such an action include the following:

- Develop, strengthen (if necessary), and enforce regulations which give local areas the legal authority to eliminate cross-connections that allow sanitary sewage or industrial wastewater to enter storm drainage systems.
- Develop and implement a field program to search for, detect and control domestic, commercial or industrial cross-connections.
- Develop and implement a field program to search for, detect, and control sanitary sewer leaks and areas where surcharging or overflows would be most likely to occur.

PREVENT RAINFALL AND RUNOFF FROM CONTACTING POTENTIAL CONTAMINANTS - This is a well established standard practice that has obvious benefit. It applies primarily to industrial or commercial sites.

- Educate re: the need to keep rainfall and runoff from contacting potential contaminants. Describe typical examples of the problem and practical solutions.

- Develop and implement regulations to require covers for outdoor storage areas that contain contaminants. Keep runoff from passing over areas that contain contaminants. Emphasize good housekeeping for open loading-unloading areas.
- Develop and implement a field program to search for, detect and correct situations where rainfall or runoff presently contact potential contaminants.

PROPER USE AND DISPOSAL OF MATERIALS BY HOME-OWNERS - The contaminants addressed by this control activity include materials such as fertilizers, pesticides and herbicides, oil and antifreeze, paints, and solvents. Specific actions for preventing the discharge of household contaminants include the following:

- Educate re: the proper storage and use of fertilizers, herbicides and pesticides; application methods, rates and frequency appropriate for the area; and the potential environmental damage that can be caused by these materials. Identify alternative methods for controlling insects and weeds (e.g., physical controls, biological controls, less toxic chemicals).
- Educate re: the need to keep oils, paints and similar contaminants out of storm drains; the potential environmental damage that can be caused by these materials: and acceptable disposal methods. Describe typical examples of the problem and practical solutions.
- Develop and implement programs and set up receiving facilities and procedures for specific pollutants such as crankcase oil, pesticide or paint containers, and other potentially harmful chemicals. Recycle if possible. The success of such a practice depends on the number and location (convenience) of stations and the awareness of the community about the effect of pollutants on the environment.
- Research, strengthen (if necessary), and enforce existing regulations which give local areas the legal authority to prevent improper disposal of pollutants into storm drainage systems.
- Label storm drain inlets and provide signs along the banks of drainage channels and creeks explaining the environmental impacts of dumping wastes.
- Develop and implement a field program to search for, detect and prevent dumping or the routine discharge of pollutants into storm sewers, drainage channels and urban streams. This should involve re-evaluating previous decisions to allow certain relatively clean waters to be discharged to the stormwater system.

Reduce Street and Land Surface Sources of Pollutants

CONTROL LITTERING AND IMPROPER WASTE DISPOSAL PRACTICES - In addition to its pollution control benefits, an effective litter control program will improve the general aesthetic appearance of an area. Because such programs can easily gain public acceptance, with visibile effects, they can assist in developing interest and acceptance of other BMPs where the relation between practice and benefit may be less obvious. Specific actions might include the following:

- Educate re: the NPS pollution impacts that result from littering and improper waste disposal practices.
- Develop, strengthen (if necessary), and enforce existing regulations which give local areas the legal authority to control littering and the improper disposal of potentially harmful or aesthetically objectionable materials.
- Provide litter bags for use in cars. Work with citizen action programs to facilitate efforts to report littering incidents and illegal dumping.
- Develop and implement regularly scheduled cleanup days and corresponding curbside collection of trash and household debris.
- Provide, collect and maintain an adequate number of litter receptacles in strategic public areas, and during major public events.
- Coordinate with efforts (by others) to establish practical controls regarding potentially harmfu packaging of consumer products.

CONTROL ANIMAL WASTES - The specific practices should consider both household pets and where appropriate, suburban livestock such as horses and waterfowl.

- Educate re: the need to clean up and properly dispose of pet wastes, and where appropriate, the need for proper management of wastes from suburban livestock and agricultural operations in the watershed.
- Educate re: the effects on water quality from large concentrations of residential and migratory waterfowl, that are common to the area.
- Develop, strengthen (if necessary), and enforce regulations which deal with the sale and/or release of domestic waterfowl.
- Provide informational signs and dispense doggie litter bags in parks and other selected areas.
- Implement and enforce leash laws and pet waste cleanup ordinances in selected public-use areas.

IMPROVE THE MAINTENANCE OF MAJOR PAVED AREAS - Activities in this category include both physical repairs to maintain pavement surfaces in good condition so that pavement debris and degradation products are not washed into storm drains, and street cleaning practices that remove litter and externally generated dust and associated pollutants that accumulate on paved surfaces.

- Improve pavement repair and maintenance programs on streets and parking areas (e.g., fill potholes, seal cracks, apply surface treatments).
- Develop and implement sufficiently intensive street sweeping programs for strategic locations. For example, paved surfaces in central business districts, shopping malls, major parking lots and industrial areas tend to produce more concentrated surface sources of heavy metals, oil and similar contaminants.
- Implement street parking regulations (e.g., alternate side parking days) where necessary for effectiveness of street sweeping programs.

INSTITUTE PROGRAMS TO REMOVE ACCUMULATIONS OF LITTER AND DEBRIS - Floatables and accumulations of debris represent an important aesthetic problem for urban streams in many areas.

- Sponsor periodic stream bank cleanup programs to remove accumulations of litter and debris in urban streams or on their banks. Floatable materials often accumulate behind roadway culverts. Encourage participation by suitable community groups (e.g.,Boy Scouts, etc.). Coordinate with public works departments for hauling and disposal of removed materials.
- Provide for routine sweeping of streets that border urban stream courses.
- Provide surveillance and enforce regulations against dumping.

CONTROL AIRBORNE POLLUTANTS - A significant source of many of the pollutants present in urban stormwater runoff is the atmospheric particles that originate from a variety of sources, and deposit on land surfaces in the urban area. Source control activities that can address this situation include the following:

- Educate re: the relationship between air pollution and NPS water quality problems, and the need to coordinate with programs (by others) that seek to reduce particulate atmospheric emissions of pollutants from individual, public, commercial and industrial sources.
- Educate re: the potential benefits of reduced automobile use by various means (e.g., ride sharing, carpooling, public transportation), and the importance of frequent vehicle inspection and maintenance efforts to reduce atmospheric emissions.
- Educate re: the proper operation of fireplaces and wood burning stoves to minimize the emissions of particulate matter.
- Cooperate with public transportation agencies, public agency motorpools, and public works departments to provide effective air pollution controls on publically owned vehicles and motorized equipment, and, where practical, on the use of alternative clean-burning fuels.

Control Erosion

CONTROL EROSION AT CONSTRUCTION SITES - The actions suggested here are directed at the control of erosion from land disturbed during construction, or the prevention of eroded materials from leaving the site.

- Educate architects, engineers, contractors, and public works personnel about the need for and practical methods for erosion control, sediment control,groundwater disposal, and site waste management and disposal.
- Develop and implement effective erosion and sediment control regulations, and requirements for corresponding construction inspection programs. These should apply to public-sector as well as private-sector construction programs.
- Develop and implement improved erosion and sediment control policies in the environmental elements of all general plans.
- Adopt policies that require all SEQRA compliance documents and all site development plans to explicitly address the topics of erosion potential, proposed erosion and sediment control plans, and enforceable mitigation measures to minimize environmental impacts.
- Require contractors to post bonds to cover potential damages from erosion or sediment deposition.

CONTROL EROSION OF UNDEVELOPED LAND AND PARKLAND - These efforts are directed at the control of erosion from essentially undisturbed urban land areas, to reduce potential adverse impacts on urban water bodies.

- Educate public works personnel and managers of parks and open space lands about the need for and practical methods for erosion control and sediment control.
- Develop and implement programs to actively search for, identify, evaluate, and prioritize erosion problems on undeveloped land, parkland or open-space urban land use areas.
- Develop and implement programs to work with landowners, tenants, and public agencies to apply practical erosion and sediment control practices.
- Develop and implement practical programs for revegetating and otherwise restoring eroding areas (e.g., areas damaged by fires, off-road vehicle use).

Land Use Planning

ZONING REGULATIONS - Appropriate zoning ordinances may be used in sensitive areas to provide for development patterns that are compatible with control of NPS discharges and the protection of receiving waters.

- Zone to limit dwelling unit density and control the amount of on-site runoff and pollutants generated by limiting the impervious surface area created.
- Restrict development adjacent to streambanks.Require vegetated buffer strips along streambanks.
- Restrict development on sites with soils and slopes that are susceptible to serious erosion.

Limit The Directly Connected Impervious Area -

- Develop planning guidelines illustrating favorable development techniques.
- Use grass swales for drainage in preference to curbs and gutters and piped drains, where feasible.
- Encourage use of cluster housing, buffer strips, open space, or other patterns that reduce the quantity of runoff from the site.
- Avoid direct connection of roof leaders to drain pipes or paved surfaces.

Require Physical Controls For New Developments -

- Require the installation of detention basins or infiltration devices as BMPs for the control of the quality and/or quantity of runoff, and for control of peak flows on all new development sites.
- Develop specific guidelines for design and construction of these devices.
- Provide for the necessary supervision, inspection and enforcement of regulations to insure compliance.

Other Control Measures

CONTROL OIL AND GREASE - Automobile operation and maintenance is the principal source of oil and grease that can result in objectionable films and sheens on the surface of receiving waters. Fractions that remain in solution may contribute toxic contaminants. Food service facilities may contribute animal fats and greases (vs hydrocarbon based) to runoff.

- Educate re: the effective use of *housekeeping* practices, oil and grease traps, the use of adsorbents and cleaning compounds for controlling oil and grease at gas stations, automotive repair shops, parking areas, commercial and industrial facilities, and food service facilities.
- Educate re: the need to provide adequate and sufficiently frequent vehicle inspection, and to maintain efforts to reduce leakage of oil, antifreeze, hydraulic fluid, etc.
- Develop, strengthen (if necessary), and enforce regulations which give local areas the legal authority to require oil and grease controls in areas that are significant sources (e.g., gas stations, automotive repair shops, parking areas, commercial and industrial facilities, and food service facilities).
- Develop technical guidance that will facilitate efforts by responsible parties to comply with regulations requiring oil and grease controls (e.g., oil traps, plate separators, synthetic adsorbent material, grassed swales).

CONTROL LEAKS FROM GASOLINE, FUEL OIL, AND CHEMICAL STORAGE TANKS - The actions listed can help to control pollutant contributions from leaking storage tanks.

- Educate re: the environmental impacts that result from leaks and spills from gasoline, fuel oil, and chemical tanks, above and below ground.
- Coordinate with efforts (by others) to intensify the implementation of existing regulations which call for improved design of new tanks (e.g., double walls,

monitoring facilities); replacement of tanks over a specified age; self-monitoring programs; and implementation of a strategically focused spot-check program to search for, identify, test, and control leaking storage tanks.

INTENSIFY THE MAINTENANCE AND REPAIR OF STORM-WATER DRAINAGE SYSTEMS - These actions are directed at removing the pollutants that tend to be retained, and accumulate at specific locations in the stormwater drainage system.

- Determine the effectiveness of increasing the frequency of cleaning out storm sewer inlets, catch basins, storm sewer pipes and drainage channels in areas where sediments, debris, or floatable materials tend to accumulate. Develop and implement improved programs where appropriate.
- Develop and implement an aggressive field program to search for, test, remove, and properly dispose of sediment deposits in drainage channels and streams, which contain relatively high concentrations of pollutants.
- Develop and implement a program which provides a means of recording the observations of field inspection and maintenance personnel, so that this information can be used to help locate the sources of pollutants.

There is no realistic way to accurately estimate the effect such practices may have on area-wide pollutant loads or to problems in specific water bodies. There is a high degree of uncertainty associated with the ability to define what these practices really do in terms of load reduction. In addition, even assuming performance levels could be defined, the extent to which the public at large would be faithful in applying a practice will generally be uncertain.

...ADVANTAGES

- Some source control actions will be very visible and will involve high level of public awareness and involvement. They can help to generate a sense of active community participation in an overall NPS control program, and may help secure the implementation of other, less obvious, elements of a management plan.
- In addition to reducing pollutant discharges to water bodies, many will have attendant aesthetic or cosmetic benefits.

....LIMITATIONS

- Adoption (with or without enforcement) of the necessary ordinances may create negative public reactions that may have an adverse effect on other areas of the program.
- In most cases, there is no reliable way to estimate the effect of a particular source control measure on the urban NPS pollutant loads.
- Effectiveness of a practice depends on the degree to which it is applied and the geographical extent of the application. Even with appropriate regulations in place, there is no positive assurance of compliance to the extent desired.
- Developing and assigning the necessary legal authority, and adding new responsibilities to established public agencies whose budget, experience, and priorities may not relate directly to NPS control may be difficult to resolve.

Chapter Six

Recommended Actions

6.0 Introduction

The identification of planning opportunities and the selection of BMPs that should receive consideration are most appropriately guided by recognition of the general types of nonpoint sources that are potentially important in the two study watersheds. An evaluation of the characteristics of the land and water use and density in the stream corridors that were studied suggests the source categories listed in Table 6-1 to be the ones that are most pertinent and which should be addressed by a NPS management program.

To maximize its water quality effectiveness, the elements of a control program should also be selected so that they focus on the specific contaminants that have a significant influence on the water quality, uses and problems that apply. In order to develop a framework for the consideration of appropriate control actions (BMPs) for the two study watersheds, the water quality differences that are the most significant, and have a good probability of being primarily associated with development features, have been summarized. The contaminants involved, and their probable major sources are used as a basis to focus attention on the most appropriate kinds of stormwater runoff BMPs that are emphasized in the program recommendations presented later.

6.1 Relation Between Environmental Quality and Density of Land/Water Uses

The environmental quality differences between Neguntatogue Creek and Beaverdam Creek that are the most significant, based on water quality parameter measurements and visual observation, were limited to the items listed below. In each case, higher levels of pollutants were observed in Neguntatogue Creek, which has the greater degree of urban development. Probable (or possible) sources of most significance are identified for each of these water quality elements.

SEDIMENT METAL CONCENTRATIONS - Copper, lead and zinc have been documented in other studies to be commonly found at elevated levels in runoff from urban areas and highways (U. S. Environmental Protection Agency 1983; Woodward-Clyde Consultants 1989). Their accumulation in the estuarine sediments of the two streams in significantly different amounts can be taken as evidence of cumulative effects of urbanization. A specific, non-stormwater source in Neguntatogue Creek cannot be ruled out at the moment, but such a source (e. g., an unknown illicit discharge) is considered unlikely to be the major source of these pollutants. The most likely major source of these metals is stormwater runoff originating from the heavily trafficked roads, such as Montauk and Sunrise Highways, and heavily used parking lots and curbside parking areas. Another source of metals is boating-related activity. The higher traffic densities and the greater concentration of vehicles and boats in the Neguntatogue Creek watershed are consistent with the observed sediment data.

Both streams have low levels of these metals in their freshwater sections. The high flow velocities and short residence time in these sections tend to keep levels low. High metal levels would tend to occur in the estuarine segments where sedimentation and accumulation would be enhanced by the reduced velocities, longer residence time and internal estuarine circulation patterns.

BENTHIC MACROFAUNAL ABUNDANCE - The fact that benthic organisms were never found at three of the marine stations on Neguntatogue Creek is considered significant. The results from benthic surveys at Beaverdam Creek support the contention that under natural conditions, impoverished communities may exist periodically in portions of estuarine streams. Low dissolved oxygen levels in bottom waters, undoubtedly play an important role. However, the toxic potential of the high sediment metal concentrations is considered to exert some degree of influence on the overall result.

SOLUBLE NITROGEN FORMS (AMMONIA AND NITRATE) -Additional monitoring is needed to specify relative differences in nitrogen levels in Neguntatogue and Beaverdam Creeks. Feller's Pond on Neguntatogue Creek, and the waterfowl population it supports, could be an important source of these nutrients. Also, septic tank systems that remain in use, although sewer connection is available, are also a possible contributor to the higher Neguntatogue nitrogen concentrations.

Conversely, the low nutrient levels in Beaverdam Creek may result from the higher algal levels and the wetland areas in this watershed. Either or both of these factors could play a role in reducing the nutrient concentrations that would otherwise be present in the water column.

FLOATABLES, SHEENS AND OTHER LITTER - Floatable materials consisted of paper and plastic containers. The obvious source is litter, either directly discarded into the stream or washed in with stormwater from streets or parking lots. The probable sources of oily sheens are the washoff of street deposits of oily materials originating from vehicles, and boating activity. Other litter included beverage cans, etc., which were most likely dropped directly into the stream or onto its bank.

DISCUSSION

There are differences in water quality and general appearance of the two streams that are attributable to the overall net influence of the differences in level of development. The most significant of these differences were identified above.

The monitoring data on various environmental quality parameters collected in this study do not permit any definitive statements to be made concerning the specification of the *precise* relationship between land and water use types and particular water quality concentrations, pollutant loads and biological impacts. This limitation results from a combination of the complexity of a variety of *natural* factors,such as seasonal dissolved oxygen depletion, the considerable variability of stormwater runoff and its impacts, and limits to the amount of detail that can be developed from monitoring programs with temporal and spatial constraints. However, different concentrations of certain contaminants and their impacts were detected between the two streams, and these can be attributed to differences in the types and density of development extant in the watersheds.

TABLE 6-1

Nonpoint Sources of Pollution to Neguntatogue and Beaverdam Creeks

Stormwater Runoff -	direct discharge from streets and paved surfaces in the urban areas to surface waters via storm sewers, drainage ditches, road ends, etc.
	discharge to surface waters from unpaved surfaces, e.g., lawns, woodlands, tilled agricultural lands.
Septic Systems -	discharge to ground water from waste disposalsystems serving residential and other uses located in low depth to ground water areas adjacent to surface waters.
Boating Activity -	direct discharge from waste disposal systems on boats and houseboats.
	washoff of boat and yard materials, oils, paints, etc
Wildlife -	fecal material from waterfowl and other warmblooded animals
Illegal and/or Accidental Waste Disposal Activity -	the potential exists for the direct discharge of wastes to surface waters via improper handling of materials, the intentional disposal of wastes, and accidents, e.g., fuel spills.
Toxic Waste Sites -	the potential exists for the leaching of hazardous materials into ground and surface waters from toxic waste sites, e.g., active and inactive landfills, highway maintenance yards, sand mining operations.

The relative contribution of pollutant loads to the creeks from marinas could not be determined from the results of the field monitoring program. However, intensive marina activity along Neguntatogue Creek poses water quality impacts due to the wastes generated from marina operation and boat maintenance. Such wastes include sewage, bilge water, used oils, oil filters, solvents, waste paints, used batteries, empty contaminated containers, etc. (Resource Planning Associates 1989). It is noted that very high concentrations of TBT (tributyltin; a toxic constituent in bottom paint) have been found in the bottom sediments of Neguntatogue Creek.

6.2 Recommended Actions

The recommendations presented below are based on the comparative analysis of land use and environmental resources in the Neguntatogue and Beaverdam Creek study areas, and on the results of the environmental quality monitoring program involving surface waters in both watersheds. They are not driven solely by the desire to improve or maintain water quality. Aesthetic, open space and terrestrial habitat considerations also justify the recommended actions. The recommendations are keyed to the particular watersheds addressed in this study, but they can be considered as part of a broader program for the remaining 36 stream corridors tributary to the bay. An overall strategy should be designed and implemented to improve the environmental quality of Great South Bay as a whole, via actions that would reduce nonpoint source pollutant loadings.

The applicability of some of the controls discussed in the two case studies to other stream corridors will depend to a large degree on existing development patterns and the characteristics of site-specific problems. The range in conditions encountered in the urban and semi-rural case study watersheds will typify situations likely to be found in most other streams. An exception is the Patchogue River, which has two point sources discharges (the Patchogue Village and Watergate Apartment sewage treatment plants). In this sense, the case studies serve as prototypes for nonpoint source control technique application in the other stream corridors. Some of the recommendations are generic, i.e, locations for application are not specified, and they apply to activities and practices that occur at locations throughout the watersheds.

Table 6-2 presents a complete listing of all of the BMP types that were described in Chapter 5, and includes an assessment of their individual applicability in each of the study watersheds. Specific recommendations for each watershed are described in sections 6.2.2 and 6.2.3.

6.2.1 Stream Corridor Protection Programs

The recommendation that calls for the implementation of stream corridor protection programs applicable to all of the streams tributary to the Great South Bay is of particular significance to stream and bay environmental quality . It can be used to engender public support for stream corridor protection activities from both the management and regulatory perspectives; and is a priority for both the Neguntatogue Creek and Beaverdam Creek study areas:

Establish stream corridor protection programs at the town level that would encompass all of the tributary streams to Great South Bay within town and village jurisdiction. This program should have components dealing with public education, litter reduction, stream corridor improvement and surveillance.

- A public awareness/education program to raise public consciousness of the impacts of nonpoint sources of pollution, improper litter/debris disposal, and streambed alteration on stream and bay water quality should be pursued. Such a program would help to motivate cooperation to reduce the discharge of floatables to fresh and marine surface waters and other nonpoint sources of pollution. For example, citizens should be encouraged to adopt lawn maintenance practices that reduce nutrient and toxic chemical loadings to ground water and surface waters.
- Improve existing programs to control littering.
  - Conduct routine cleanup of parking lots, particularly those found at fast-food outlets or other operations which tend to generate litter.
  - Implement more frequent street sweeping, where appropriate, with curbside parking regulations that are necessary to make this effective.
  - Provide receptacles at appropriate locations (and empty them at appropriate intervals).
  - Enforce ordinance provisions as appropriate.
- Augment existing public works efforts in litter and debris removal, and catch basin maintenance.
  - Floatables and debris tend to be trapped and accumulate behind some culverts passing under streets and roads. Enhanced programs to remove retained floatables at regular intervals should be considered.
  - Investigate the feasibility of installing screens or booms at strategic underpasses, and provide easy access for cleaning.
  - Consider sponsoring periodic *clean-up days* to remove debris from stream banks, beds and adjacent areas. Seek the involvement of citizen groups, or organizations such as the Boy Scouts and Girl Scouts.

TABLE 6-2
Applicability of BMPs for Control of Nonpoint Source Pollution in Urban and Semi-rural Watersheds

	BMP Control Measure	*Urban Watershed*	*Semi-rural Watershed*
A	*DETENTION BASINS*		
	— dry ponds	no*	yes**
	— wet ponds	no	yes
	— extended detention dry ponds	no	yes
B	*RETENTION DEVICES*		
	— infiltration basins	no	yes
	— trenches & dry wells	yes	yes
	— porous pavement	yes	yes
C	*VEGETATIVE CONTROLS*		
	— basin landscaping	no	yes
	— wetlands	no	yes
	— grassed swales	no	yes
	— filter strips	no	yes
D	*SOURCE CONTROLS*		
	— exclude inappropriate discharges to storm drains		
	• illicit connections	yes	yes
	• exposed contaminants	yes	yes
	• home material disposal	yes	yes
	— reduce street and land sources		
	• litter control	yes	yes
	• animal wastes	yes	yes
	• pavement maintenance	yes	yes
	• remove litter & debris	yes	yes
	• airborne pollutants	yes	yes
	— control erosion		
	• construction sites	yes	yes
	• parks & undeveloped land	no	yes
	— land use planning		
	• limit direct connections	no	yes
	• control of new development and redevelopment	yes	yes
	— other control measures		
	• control oil and grease	yes	yes
	• storage tank leaks	yes	yes
	• drainage system repair & maintenance	yes	yes

*no indicates that there are MAJOR constraints to the application of the specified BMP

Provide appropriate department of public works support for hauling away the removed trash/debris.

- Assign agency personnel and/or volunteers the task of inspecting stream corridors on a regular basis. Such a surveillance program would: allow for targeting resources to address priority problems at specific stream locations; enable the detection and elimination of non-stormwater discharges to drainage systems; assist in the mitigation and prevention of undesirable activity, such as stream bed alteration, bulkheading, filling, etc., undertaken by owners of stream shoreline/bed property; and contribute to the expeditious clean-up of accidental hazardous or toxic pollutant spills.

Stream corridor protection programs would provide the mechanism for coordinating New York State, Suffolk County, town and village activities with those of the private sector in fostering the development and implementation of plans for the streams on a priority basis. The regulatory foundation for stream protection is in place under the New York State Freshwater Wetlands Act (Article 24 of the ECL) and the Stream Protection Act (Article 15, Title 5 of the ECL). On the town level, regulations such as Section 8686-17 of the Babylon Town Code prohibit the dumping of wastes into canals, creeks, etc. However, additional regulatory controls on nonpoint sources are requied. Effort at all jurisdictional levels is required to assure development, adoption and vigorous implementation of consistent standards to control development and nonpoint source pollution along stream corridors.

Suffolk County has developed a plan to protect Orowoc Creek in cooperation with the Town of Islip. The tools used in this plan to protect the stream, e.g., acquisition, dedication of tax lien parcels to the County Nature Preserve, and conservation easements, could also be applied to other streams tributary to Great South Bay.

6.2.2 Neguntatogue Creek

Opportunities to reduce nonpoint source pollution to surface waters in the Neguntatogue Creek study area are principally limited to those situations that will arise as commercial, industrial and residential areas redevelop and as infrastructure facilities are improved/maintained. The intensity of the existing development pattern also precludes, or places limits on, the use of structural nonpoint source control options, such as detention basins, and on vegetative controls. For this urban watershed, emphasis has been placed on source controls.

- Require mandatory connection of those residences and commercial and industrial establishments to the SWSD #3 that are not presently serviced by this facility. Separate systems used for the disposal of laundry wastewater and other wastes should also be eliminated. Such connections will help to reduce nonpoint source loading to ground water from cesspools, septic tank/leaching field systems, domestic laundry activity, etc. The quality of ground water in areas with minimal depth to ground water should improve over time, thus reducing this source of surface water contamination.
- Take actions to reduce urban stormwater generation and direct discharge of urban stormwater to Neguntatogue Creek during periods of significant reconstruction involving commercial, industrial and residential development and associated infrastructure.
  - Implement erosion control practices for construction sites.
  - Require redevelopment plans to consider use of grading, swales vs. curb and gutter, and alternative site plans that minimize impervious areas to eliminate, where possible, or reduce the amount of direct runoff to Neguntatogue Creek.
  - Require the installation of stormwater detention basins (or pollutant reduction equivalent) where appropriate and feasible to be part of any new development or redevelopment.
- An engineering analysis to evaluate alternatives to reduce the generation and direct discharge of stormwater runoff into Neguntatogue Creek should be conducted as part of a broader study involving other watersheds tributary to Great South Bay. On the basis of this regional study, eliminate piping and runoff directly to the streams at locations where this is feasible and most beneficial. Where site conditions and drainage requirements permit, have stormwater runoff pass over a vegetation buffer strip, or along a vegetated swale, before entering the stream. Use of this practice to handle runoff from high traffic density highways and from parking lots should be given high priority by New York State, Suffolk County, Town of Babylon and Village of Lindenhurst. The feasibility of applying BMPs to existing development should also be considered.
- Use appropriate BMPs to enhance infiltration to obtain soil filtration of metals. The relatively high water table in much of the area will limit opportunities, but this approach should be explored for the runoff from major highways, which are probably a major source of the metals entering the stream.
- Enact local laws that require implementation of BMPs governing activities such as fuel pumpage and storage; proper use and disposal of certain paints, additives, etc., associated with marina operation. Applicable source control BMPs for use in marinas are contained in Resource Planning Associates (1989). Control future development of additional marina facilities on Neguntatogue Creek and other Great South Bay tributaries for both navigational safety and environmental concerns by using tools such as: zoning restrictions; limits on the types of boats; limits on the number of slips permitted per unit area; establishment of pier lines; and restrictions on the discharge of marine sanitation devices.
- Eliminate non-stormwater discharges to the storm drainage system. Implement a program to check for the presence of such discharges. The results of this study provide no evidence of such a condition, but do not preclude the existence of some. General experience suggests the probability of a number of non-stormwater discharges in any area. Take appropriate action to have such discharges removed.
- This study acknowledges the ongoing Suffolk County Flow Augmentation Needs Study and its preliminary recommendation to augment streamflow in Neguntatogue Creek via the alternative of groundwater pumpage with discharge to Feller's Pond. It is not known at this time when the need will arise to augment streamflow and what funding priorities will be set for the 12 stream augmentation projects under consideration in the area serviced by the SWSD #3 where ground-water table elevations are expected to decline. Certainly, monitoring of streamflow and wetland vegetation should be integrated into the stream corridor protection programs recommended in section 6.2.1 for affected streams in the western portion of the Great South Bay watershed.

6.2.3 Beaverdam Creek

As opposed to Neguntatogue Creek, there are many opportunities to mitigate the discharge of nonpoint source pollution to Beaverdam Creek. The use of non-structural BMPs is feasible in this watershed (and other semi-rural watersheds tributary to Great South Bay), given the fact that the stream corridor retains many natural characteristics and there is a significant amount of land available for development in the watershed. This flexibility also increases the feasibility of structural BMP implementation where site conditions warrant their use.

- Curtail development activities within the critical stream corridor protection zone. The boundary of this zone is drawn to include all tidal and freshwater wetlands with a 100 foot setback, the area within the 100-year tidal floodplain, and where the depth to ground water is 5 ft. or less. No bulkheads should be constructed along the stream corridor .
- Preserve the stream corridor in the northern portion of the study area through exchange of ownership (i.e., private to public) or transfer of development rights (TDR). This will require cooperation and agreements for replatting old filed subdivisions and the exchange of parcels owned by Suffolk County, the Town of Brookhaven, the Brookhaven Fire District and private parties. The Opportunities map

delineates the TDR Sending Area, an environmentally sensitive area near the stream, where private owners would exchange ownership or TDRs for publicly owned properties outside of this boundary, such as the TDR Receiving Area to the west. The purpose of such an exchange would be to protect the TDR Sending Area from development through either public ownership or ceding of development rights from private properties to public or quasi-public entities. Furthermore, any public lands within the TDR Sending Area should be retained in a nature preserve category for preservation purposes. It is emphasized that the Brookhaven Fire District properties located in this TDR Sending Area should be exchanged for properties in a location more suitable for firematic training purposes

- North of Montauk Highway, the headwaters of Beaverdam Creek flow through a vacant, privately owned 9.5 acre parcel. (See Opportunities map.) This land should be preserved through TDR, or through acquisition if necessary, to protect freshwater wetlands and stream water quality.
- Cluster residential development on those parcels that are vacant or currently used for agricultural purposes, and that border or are near the stream and associated wetlands, so as to maintain woodland and/or field buffer strips along the stream corridor.
- Take action to reduce urban stormwater generation and direct discharge of runoff to Beaverdam Creek .
  - Implement erosion control practices for construction sites.
  - Require development plans to consider use of grading, swales vs. curb and gutter, and alternative site plans that minimize impervious areas to reduce the amount of direct runoff.
  - Require the installation of stormwater detention basins (or pollutant reduction equivalent) where appropriate and feasible to be part of any new development. The goal should be to retain runoff on-site from all new development.
  - Natural swales and areas having medium to steep slopes should be protected. Where appropriate, install railroad tie check dams in existing swales to retain flow and enhance infiltration.
- Avoid drainage of runoff directly to the stream via ditches and storm drains. Where site conditions and drainage requirements permit, have stormwater runoff pass over a vegetated buffer strip, or along a vegetated swale, before entering the stream. Use of this practice to handle runoff from high traffic density highways, e.g., Montauk Highway, and from parking lots should be given high priority by New York State, Suffolk County and the Town of Brookhaven. The feasibilty of appling BMPs to existing development should also be considered.
- Use applicable BMPs to enhance infiltration to obtain soil filtration of metals. The relatively high water table in much of the area will limit opportunities, but this approach should be explored for the runoff from Montauk Highway and Beaverdam Rd., which are probably a major source of the metals entering the stream. Consider the potential of existing or created wetlands to filter/cleanse stormwater runoff.
- Continue monitoring programs to detect any impacts of the Town of Brookhaven landfill on surface water quality in Beaverdam Creek. Require appropriate action if there is evidence that leachate is introducing contaminants to Beaverdam Creek via ground-water flow.
- Determine the feasibility of rehabilitating the extensive dredged spoil disposal sites bordering the marine portions of the creek by the restoration of tidal circulation and creation of fish and wildlife habitat. This recommendation should be a part of a management plan prepared for the Beaverdam Creek Significant Fish and Wildlife Habitat.
- Eliminate non-stormwater discharges to storm drainage system. (For additional detail, see item F in section 6.2.2)
- Enact regulatory codes that require implementation of BMPs governing activities such as fuel pumpage and storage; proper use and disposal of certain paints, additives, etc., associated with marina operation. Should ultimate protection be desired, consideration should be given to the eventual phase out of all commercial marina uses along the creek. This would necessitate a change in zone from commercial to A-2 residential for the parcel near the northern end of the marine portion of the creek, south of Beaverdam Road.

6.3 Suggested Refinements to the Field Sampling Program

The ability to compare the quality of Neguntatogue and Beaverdam Creeks hinges on the ability to adequately document the nature and variability of two complex environments. Little historical data were available on either stream to assist in the formulation of the field sampling program used in the present study. Experience gained in the course of this study suggests a number of changes to the field sampling program that would improve the effectiveness of future studies on the steams and other Great South Bay tributaries.

While these water quality concerns and impacts are likely to be greatest during the summer months, sampling at all seasons would provide a more comprehensive picture of the nature and quality of environmental conditions in these streams.Knowledge of winter water quality conditions would lead to better understanding of the processes causing the observed problems during other seasons.

The presence of several classes of pollutants associated with non-point source pollution, such as oil and greases, as well as various organic pollutants (pesticides, herbicides, industrial compounds) should be assessed in future stream monitoring efforts.Documenting their levels is necessary to detect sources and assess impact on small stream systems.

Nutrient levels and phytoplankton populations are closely coupled and respond quickly to changes in meteorological and terrestrial input conditions.To further describe the temporal variability of these parameters, weekly sampling is advisable.

The mortalities observed in the ambient water bioassays, particularly among the finfish tested, indicate that some portions of the fresh-water and marine reaches of both Neguntatogue and Beaverdam Creeks may be acutely toxic during the warm weather months. Additional studies should be undertaken to better document the extent to which this occurs and to identify the factors causing these mortalities.

Future studies should investigate boating activity with specific sampling procedures to determine environmental impacts from such water uses.

This study focused on fundamental physiochemical determinants of water quality and the relative health of lower trophic level populations. Additional studies should also incorporate analysis of the health of consumers at higher trophic levels, particularly finfishes, to determine potential broader impacts on natural resources.

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